The Literature
# of the
Ten Principal Food Fishes
# of the North Sea.

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THE LITERATURE OF THE TEN PRINCIPAL FOOD FISHES OF THE NORTH SEA

IN THE FORM OF COMPENDIOUS MONOGRAPHS

WITH 10 PLATES

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
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This little work is published with the intention of giving a general review in concise form, of the most important literature on the ten principal fishes of the North Sea. On account of the extensiveness of zoological literature at the present time, and of the difficulty frequently great, of obtaining papers concerned with fisheries (official reports, etc.) the idea of making a truly complete summary of all the literature was given up at the very beginning. For such a summary years and not months would be required.

The main object of the work was but to provide my colleagues who are engaged in fisheries research with a vademecum of the literature. I have thought it better therefore, to leave aside almost entirely the purely scientific and morphological literature (on comparative anatomy, histology and embryology).

I have been greatly aided in my work in various ways, and more especially by Prof. Dr. FR. HEINCKE, Prof. Dr. E. EHRENBAUM and Dr. H. M. KYLE. It is for me a pleasant duty to express my thanks here for their assistance. Dr. KYLE has in addition, the credit of translating this work into English, and my best thanks are due to him for that also.

The accompanying plates illustrate the eggs and some stages in the development of each separate fish. All the figures are copies of drawings already published, and are reproduced in a modest and inexpensive manner (by autography). With the request that they will pardon the theft so perpetrated, I would tender my thanks to the original authors.

Kjøbenhavn, 30th July 1903.

P. P. C. H.

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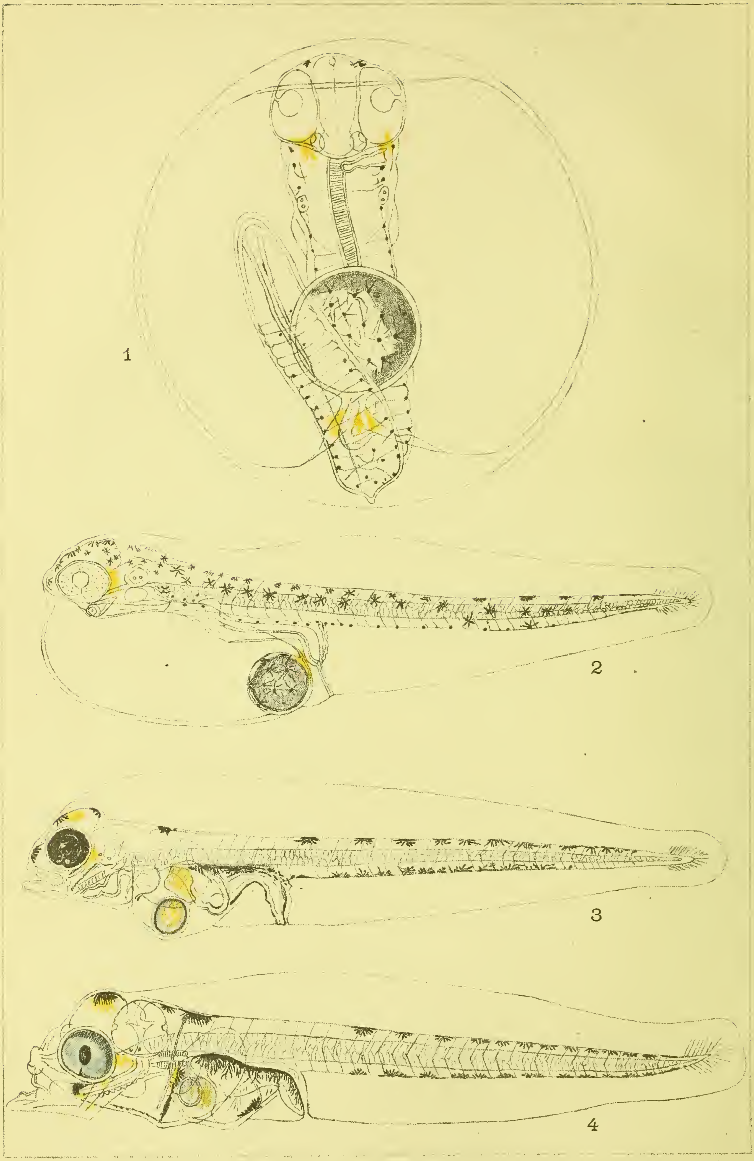


AXEL E. AAMODT KJØBENHAVN

1. *Scomber scomber, L.*

1. Mackerel: *Scomber scomber*, L.

Plate I

Common Names:

Danish:	Makrel.	Dutch:	Makreel.
German:	Makrele.	Norwegian:	Makrel.
English:	Mackerel.	Russian:	Makrel.
Finnish:	Makrilli.	Swedish:	Makril.
French:	Maquereau.		

Description of the Species: Detailed descriptions are given by Fries and Ekström (29), Kröyer (58), Günther (36), Day (18); a brief diagnosis by Möbius and Heincke (76, b).

We are indebted also to Brown Goode and his co-workers Collins, Earll and Howard Clark, for an extensive work (441 p.) which appeared in 1884 ["Materials for a history of the Mackerel Fishery (of the United States)" (35)]. The portion treating of the natural history of the mackerel is dealt with by Brown Goode, and contains much that is also of importance for the knowledge of the mackerel of the east side of the Atlantic Ocean.

As regards variations of this species Day, 1884 (18; Vol. I, p. 85), mentions a few cases and gives references to literature: the question of 'races' amongst the mackerel has been studied by Garstang 1898 (32), who distinguishes an American from an European race and takes into consideration a subdivision of the European race into an Irish and a North Sea race; also by Williamson 1900 (91, e), who considers it to a certain extent probable that the mackerel from the Clyde, from Barra and Stornoway, and from Aberdeen shew race-distinctions.

EXPLANATION OF PLATE I

Fig. 1 Egg, from tow-net. × 66 ca.
„ 2. Larva, soon after hatching. × 29.
„ 3. Larva, about five days old. × 29.
„ 4. Larva, about nine days old. × 26.
All the figures are from Holt, 1893 (49, d; Plate I, fig. 2, 3, 5 and 7).

Areal Distribution: Northerly: In Europe as far as the furthest north of Norway but not observed on the Murman-coast: in America as far as Labrador. Seldom above 62° north latitude, and not known at Greenland and Iceland, EHRENBAUM, 1901 (21, c; p. 74).

Easterly: As far as the Russian boundary of Norway; in the Baltic it penetrates to the Prussian, Russian, and Finnish coasts, but is a rare visitor there, MÖBIUS and HEINCKE, 1883 (76, b; p. 39).

Southerly: Atlantic Ocean to 30° north latitude, and Mediterranean; on the American side of the ocean to Cape Hatteras, according to BROWN GOODE, 1884 (34; p. 281).

Westerly: As far as the American coast.

N.B. CUNNINGHAM, 1896 (16, n; p. 315) gives noteworthy information of the coming and going of the mackerel in the neighbourhood of the English coast. THOMAS SCOTT, 1900 (87, c; p. 277) says that from time to time shoals of mackerel have been observed both in the Clyde and Loch Fyne.

Bathymetric Distribution: They swim near the surface. In August 1851 when they appeared in great shoals in Kiel Bay, the surface of the sea where they were swimming seemed as if a strong breeze were blowing over it; MÖBIUS and HEINCKE, 1883 (76, b; p. 39).

According to DAY, 1884 (18; p. 85), it is in January or February "that these fishes usually commence to move from the deeper portions of the Atlantic towards the British coast". Where these places lie, their depth and so on, is however unknown. CUNNINGHAM, 1896 (16, n; p. 315) says that the mackerel at Plymouth are at their rarest in December and January, and that this is probably the time when the fish live furthest from the coast and are feeding in more remote waters, where the temperature is higher. M'INTOSH and MASTERMAN, 1897 (71; p. 160), say that "the surface water in the open seas is the haunt of this species throughout life"; and at another place, "it is now pretty well ascertained that the middle and eastern parts of the Atlantic form the home of the mackerel, which migrate hence into British waters".

ALLEN, 1897 (2; p. 28), says the facts seem to indicate, that the mackerel when they leave the coast betake themselves to the deeper layers of the ocean at a greater or less distance from the coast — perhaps at no great distance from their summer resorts.

Food: DAY, 1884 (18; p. 86), mentions as food of the mackerel: species of the herring family and their young; in May, young of the rockling (*Motella*), small medusæ, young of *Portunus pusillus*, ampipods, and fish eggs.

MÖBIUS and HEINCKE, 1883 (76, b; p. 38), say that the mackerel

chiefly feeds on small swimming crustacea (Copepods, *Mysis*) and pursues the jelly-fishes in order probably to feed upon the 'medusa-fleas' (*Hyperia galba*) which frequent the jelly-fishes.

Holt, 1892 (49, b; p. 460), examined in 1890 the stomachs of 88 mackerel. All contained copepods, mostly *Calanus*; many also had sandeels.

Cunningham, 1896 (16, n; p. 313), mentions that the mackerel feeds on small surface animals, copepods, fish-eggs and so on, when no small fish are to be had. For this purpose the gill-raker apparatus, which is developed to the same extent as in the members of the herring family, is useful. During August this naturalist found small sprats in their stomachs, and in November nothing but small pilchards (*Clupea pilchardus*).

According to Allen, 1897 (2; p. 9), the food is of two kinds: plankton i. e. pelagic life, during spring and first half of the summer, but small fish in the second half of the summer and in autumn.

Reproduction: Marion, 1889 (66), declares that the sexual organs were far advanced in development in fish of 20—24 cm in length which he examined in February, and which he considered as one year old.

The smallest ripe female observed by Cunningham, 1892 (16, h; p. 232), in June was 29,5 cm, the smallest ripe male 30,3 cm. Cunningham considered that these fish were two years old.

"Sexual maturity appears to be attained at a length of 11—12 inches", M'Intosh and Masterman, 1897 (71, p. 165), which means a length of 28 to 30,5 cm.

Amongst 918 mackerel caught in the neigbourhood of England, Garstang, 1898 (32; p. 249), found 423 males and 495 females, or 117 females to 100 males. With few exceptions he found that the number of the females exceeded at each size the number of the males. Neither he nor Cunningham, however, determined these proportions in spawning fish.

Williamson, 1900 (98, e; p. 327), makes several remarks on the reproduction and weight of ripe and unripe mackerel in his work on the mackerel of the east and west coast of Scotland. The ripe fish had a length of 27 to 43 cm.

Spawning-period: Cunningham, 1889 (16, c; p. 25), says that the mackerel in the neigbourhood of Plymouth spawn chiefly in June and the first half of July, and the individual spawning is over within a short space of time.

Holt, 1892 (49, b; p. 392), on the west coast of Ireland examined 15 mackerel of 40,5 cm in length on the 1st April, and found none of them ripe. On the 12th May another 50 specimens were examined; the males were all ripe, the females half or three parts ripe and but few quite ripe; on the 18th June, of 17 males 33 cm long, some were ripe, some half or three parts ripe. Of 15 females examined at the same time some were half ripe, some three parts ripe, one quite ripe and one spawned. 4 other females of 23—28 cm had spawned. Pelagic eggs of the mackerel were obtained at the end of April, the beginning, the 16th and 28th of May. HOLT believes that various schools approach the coast of Ireland one after another in order to spawn there at various points, and that the largest fish come first.

WILLIAMSON, 1899 (98, d; p. 98), found the mackerel eggs in Loch Fyne mostly in July, although they had already been obtained in June in considerable numbers. This fish spawns in Loch Fyne in July and August, as was previously remarked by BROOK, 1887 (7, e; p. 245).

HEINCKE and EHRENBAUM, 1900 (38; p. 276), state briefly that the general consensus of opinion — which is remarkable — gives the months of May to July or beginning of August as the spawning-period of the mackerel in the North Sea and neighbouring waters.

Spawning-regions: G. O. SARS, (84, b; p. 31), was the first who in 1865, discovered the floating eggs of the mackerel near the south coast of Norway ("langs vor Sydkyst"). The mackerel approach the coast in summer in order to spawn.

CUNNINGHAM, 1889 (16, c; p. 27), observed spawning mackerel for the first time on the 24th May 1888, east of the Eddystone lighthouse 14 miles from Plymouth Sound.

HOLT, 1893 (49, d; p. 10), collected in the surface net a number of eggs of this fish on the 30th April 1891 not far from Davalaun, and on the 4th May in Cleggan Bay on the west coast of Ireland.

HEINCKE and EHRENBAUM, 1900 (38; p. 276), say that the neighbourhood of Heligoland is visited every year with great regularity by shoals of spawning mackerel. The eggs are obtained at less or greater intervals in very great numbers usually on a limited area: different shoals visit the waters of Heligoland one after the other and independent of one another.

Eggs: G. O. SARS, (84, b; p. 31), described in 1865 the egg of the mackerel as floating in the water sometimes in one direction sometimes in another, provided at the upper pole with a fine clear oil-globule and thus easily recognisable.

CUNNINGHAM, 1889 (16, c: p. 31), says that the fertilised egg of the mackerel is spherical and transparent, having a diameter of 1,22 mm. On the surface of the yolk lies a large oil-globule which likewise is

colourless and has a diameter of 0,32 to 0,33 mm. The egg-capsule is thin and shews neither sculpture nor uneveness on its outer surface.

Holt's description, 1893 (49, d; p. 11), agrees in essentials with that of Cunningham. According to him the diameter of the egg varies between 1,21 and 1,33 mm. Concerning the oil-globule, Holt says that it presents a dense dark boundary "and is clouded all over, so as to appear gray by transmitted light. This cloudiness appears to me to be a great aid to identification".

According to Wemyss Fulton, 1898 (31, i; p. 114), the diameter of the ripe egg is 1,25 mm.

Holt, 1898 (49, g; p. 113), mentions that the eggs described by Agassiz and Whitman, 1885 (1; p. 36) agree closely with those of the mackerel.

Heincke and Ehrenbaum, 1900 (38; p. 276) found the oil-globule always colourless, and describe the egg as having homogeneous yolk and large oil-globule of 0,25 to 0,28 mm. According to them, the diameter is 1 to 1,4 mm. The embryonic pigment is black and later moss-green (by reflected light, yellow to brownish) and its distribution is very characteristic.

Development: Cunningham, 1889 (16, c; p. 31), gave a detailed description of the development in the egg. At a temperature of 14,5° C., eggs took 6 days to hatch out (from 29th June to 4th July). In this place Cunningham gives no description nor figure of the larva, but in 1891 (16, f; p. 71), he supplied that want. In the work of Holt, 1893 (49, d; p. 10), figures are given, first of a larva shortly after hatching then of larvæ five, seven, and nine days old. Cunningham in his book on "Marketable British Marine Fishes" gives figures of a larva just hatched and of one 4 days old; the latter of these had already been drawn and described by him in 1892 (16, i; p. 329).

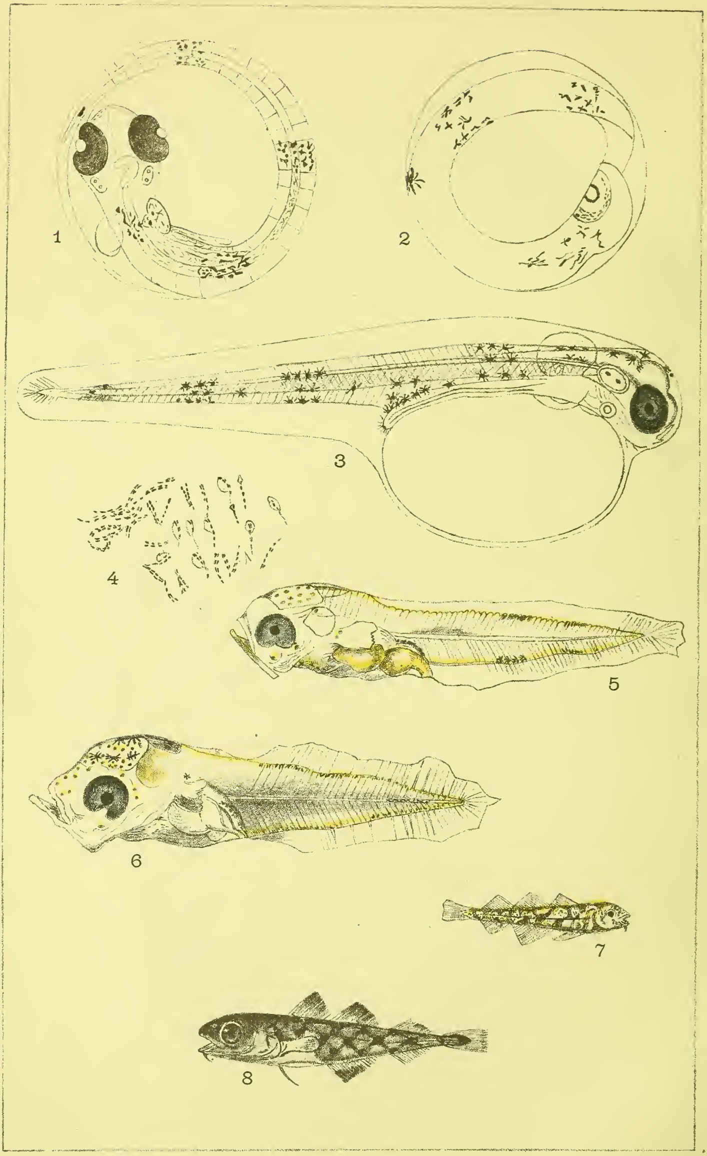
The larva just hatched is 3,98 mm (4 mm) long according to Holt, 4,23 mm according to Cunningham. The eyes are large, the mouth is not yet opened, the oil-globule lies in the posterior portion of the yolk sac. Holt describes the changes undergone by the larva until the 9th day and distinguishes the stages very clearly by figures. On that day the eyes had taken on a beautiful blue colour. They "appear a brilliant blue (by reflected light) except at the margins which are black". Some of these larvæ had reached the post-larval stage on the tenth or eleven day and their oil-globule had quite disappeared.

Concerning the later development of the mackerel we have from Holt, 1892 (49, c'; p. 396), a brief description of three larval stages of 13,75—18,5 mm in length, which were taken on the surface at the end of July. Later, 1898 (49, g; p. 112), he has given an excellent description with figures of larvæ 7 to 18 mm long, and again in 1899 (49, h;

fig. 106) a good figure of a young form. We must also mention the paper of WILLIAMSON, 1899 (98, d; p. 79) in which numerous figures of larval stages of *Scomber* are given. It is not quite certain, however, that these really belong to the mackerel.

SARS (84, c; p. 152) and DUNN (vide DAY, 18; Vol. I, p. 89) have given items of information concerning the development of the young mackerel, and M'INTOSH and MASTERMAN have endeavoured to combine the notes of these authors into one complete picture. Information with regard to the growth of the young mackerel is indeed scarce. CUNNINGHAM, 1896 (16, n; p. 314), says that he did not succeed in obtaining the young of the year at Plymouth; that the smallest he could study were caught in pilchard-nets during November 1891 and were 153 to 212 mm long. He believed that these were in their second year. Some specimens were caught on lines during June and these were 222 to 237 mm long. CUNNINGHAM considers it possible that these were also one year old.

In his work of 1897 (2; p. 1—40) on the habits and wanderings of the mackerel, ALLEN (p. 6—7) gives a detailed account of the literature and a table for the determination of the rate of growth of this fish.



AXEL E. AAMODT KØBENHAVN.

2. *Gadus morrhua, L.*

2. Cod: *Gadus morrhua*, L.

Plate II

Common Names:

Danish:	Torsk.	Dutch:	Kabeljauw.
German:	Kabeljau or Dorsch.	Norwegian:	Torsk.
English:	Cod.	Russian:	Treska.
Finnish:	Turska.	Swedish:	Torsk, Kabelja.
French:	Cabillaud or Morue.		

Description of the Species: See Fries and Ekström (29), Kröyer (58), Day (18), also short diagnosis by Möbius and Heincke (76, b).

As to the question whether a smaller race is present in the Baltic, *vide* Malmgren (55), Winther (99), Möbius and Heincke, and Petersen (80, g).

For a comparison of this and the allied species *G. virens* L. and *G. pollachius* L. in respect to certain external and osteological characters, see Williamson, 1902 (98, f; p. 228).

Areal Distribution: Northerly: as far as Bear Island, but very variable, some years at Spitzbergen, Malmgren, 1865 (65, b; p. 528); to the north of the Murman coast, Knipowitsch, 1902 (57; p. 583) and as far as Greenland.

EXPLANATION OF PLATE II

Fig. 1. Egg with embryo shortly before hatching, from life. × 32,5.
„ 2. Egg with a somewhat younger embryo, preserved. × 32,2.
Figs. 1 and 2, from Heincke and Ehrenbaum, 1900 (38).
„ 3. Larva, just hatched. × 28.
„ 4. Larva of 3rd day, very little magnified. Original drawing by E. E. Prince.
„ 5. Postlarval stage. × 15.
„ 6. Somewhat later stage with distinct pigment on the head. × 13,3.
„ 7. Young fish; natural size. Original drawing by E. E. Prince.
Fig. 3—7 from M'Intosh and Masterman, 1897 (71).
„ 8. Young fish, a little greater than natural size: from Petersen, 1902 (80, g; p. 7).

Easterly: beyond Alexandrowsk (North Russia), Knipowitsch; in the White Sea, Ehrenbaum 1901 (21, c; p. 108), and in the Gulf of Finland, Malmgren, 1863 (65, a; p. 28).

Southerly: beyond the southern entrance to the English Channel, on the coast of Brittany, likewise in the Bay of Biscay, and according to Yarrell, 1860 (101), even at Gibraltar.

Westerly: New Foundland and to the south of New York as far as Cape Hatteras, Brown Goode, 1884 (34; p. 202).

N. B. The migrations of the cod show great differences from one year to another. For the Northern Ocean, Hjort 1902 (45; p. 39), compares the observations made in 1878 at Spitzbergen by G. O. Sars with what he himself found there in 1901. With regard to its occurrence in the Baltic, the information given by Petersen 1902 (80, g; p. 22), is specially important: in opposition to the older naturalists he expresses the opinion, "that all the Baltic cod have immigrated through the Danish seas". In the same connection the experience of Fulton, 1893 (31, h; p. 189), with marked cod is also of importance; from 196 marked fish 10 were recovered.

Bathymetric Distribution: According to Lilljeborg, 1881 (61), the cod on the Norwegian coasts are met with at depths exceeding 180 m. The adult fish are not common in greater depths than 216 m, Cunningham, 1896 (16, n; p. 283); the best fishing-places in the North Sea are at depths of 70 to 100 m, Hoogendijk, (51; p. 253). On the Norwegian coast the greatest fisheries are 1. "under Land", near the Lofoten Islands, 2. "paa Bankerne" beyond Söndmöre and Romsdalen, and 3. "under Finmarkens Kyster", Collett, 1875 (15; p. 104).

According to Hjort, 1902 (45; p. 42), the depth of water over the "Fiskebanker", is less than 100 m. With regard to the occurrence of the cod in the middle of summer, they seem to avoid the deep channel, about 360 m, "som vestenifra gaar ind over Östhavet", where the bottom is composed of mud, Hjort 1902 (45; p. 56). According to the latter (p. 51 and 53) the 1 to 1½ year old cod inhabit depths from a depth near the shore of 14,5—18 m down to 360 m.

According to Th. Scott, 1900 (87, c; p. 282) the cod is common in the Firth of Clyde in tolerably deep water. In his opinion the eyes of the cod do not stand the daylight for a very long time, consequently these fish do not live in shallow water.

In treating later of the development of the cod it will be mentioned where, according to the most recent observations, the fry and the small cod up to 5 cm in length most commonly frequent.

Food: As is well known the older cod is a predaceous fish and by no means particular in his choice of food; this is composed of

very many species of fishes, crustacea, and mollusca; the younger small fish live, partly amongst seaweed ("Taretorsk") and feed on small crustacea; partly on sandy ground, and feed on worms and small fish, G. O. Sars, 1866, '67 (84, a; p. 35).

According to Collett, 1875 (15; p. 104), the cod come from the Arctic Sea during March to May towards the coast of Finmark and pursue the "Lodden", *Mallotus villosus*, which appear there at that time in enormous quantities.

In 1886, George Brook (7, d; p. 134) published a preliminary paper on the food of the cod. 300 specimens were examined and he came to the conclusion that this species feeds chiefly on crustacea, gadoids, and pleuronectids. Wherever *Aphrodite* is specially abundant it also forms an important portion of the food, especially in spring and summer. In winter the herring and the eggs of herring form the chief nourishment of the cod on the Scottish coasts. In 1887 (7, f; p. 326) the same author examined the stomachs of 48 cod — small fish of 3,2—7,6 cm in length — and found the contents to consist of copepods, and in addition amphipods, *Idothea* and *Mysis*.

Ramsay Smith, 1890 (89, b; p. 239), found that 192 out of 206 haddocks caught in the Firth of Forth, contained food. In 165 of these (85 %) were arthropods (*Crangon, Pandalus, Portunus, Nephrops, Pagurus*, etc.); in 110 (57 %) he found fish (whiting, herring, sand-eels, sprats, young cod etc.); in 22 (11 %) mollusca (*Buccinum, Solen, Pecten*, etc.); in 12 (6 %) annelids (*Aphrodite* etc.); and in 4 (2 %) echinoderms (*Ophioglypha* etc.). In 8 specimens from St. Andrews Bay he found crustacea (*Pagurus*, *Corystes*, *Portunus*, etc.), fish (whiting, herring etc.) and annelids (*Aphrodite* and *Arenicola*).

In 32 young cod, from 51 to 76 mm in length, which were taken in the Moray Firth in June and July, the same author found the following: indeterminable copepods in 13, amphipods in 10, *Caprella* and *Pseudocalanus* in 8, *Atylus* and *Thalestris* in 6 etc. Fish remains were found in 2, gastropod larvæ in 1 etc.

His later publications, 1891 (89, c; p. 228) and 1892 (89, d; p. 215) give somewhat different percentages in each case, but the results in the main were the same as those of 1890.

Herdman and Corbin, 1894 (41, b; p. 14), examined cod of the length 7,6 to 22,8 cm, and found that these were chiefly feeding on crustacea such as *Crangon*, *Mysis* and amphipods. Larger cod however begin to feed on fish (small cod, whiting, sprat etc.) and larger crustacea (as crabs and hermit-crabs).

In the years 1894 and '95 Andrew Scott (43; p. 16) and (86; p. 10) also contributed to the literature on the subject. In small cod he found only crustacea, in the larger mostly crustacea, then fish and thirdly annelids.

According to Hjort and Dahl, 1900 (46; p. 155), the 1 to 1½ year old cod live on bottom-animals, mostly crustacea.

In his extensive work of 1902, Thomas Scott (87, d; p. 505) describes the food which he found in the stomachs of cod mostly small, many indeed very small, 5—11 cm, 18,5 cm, and 50—77,5 cm, 82,5 cm and so on. The food consisted chiefly of crustacea, fish (haddock, dab etc.) and mollusca (*Cardium, Buccinum* a. o.).

Reproduction: Earll, 1880 (20; p. 714), is one of the first who has given exact information with regard to the number of eggs which the cod has, and he declares that this fish does not shed all its eggs at one time but that the spawning is spread over several weeks.

Hensen, 1883 (39, a; p. 302), also counted the eggs of the cod and found that they could be distinguished in the ovary into five well defined stages, namely into free, ripe, just becoming clear, large opaque, and small opaque. In unripe ovaries he found three distinct stages.

Cod spawn in Kiel Bay; the average size of this species in the western Baltic is 40—50 cm, Möbius and Heincke, 1883 (76, b).

Cossar Ewart and Brook, 1885 (23; p. 54), observed the spawning cod in an aquarium and described the process of spawning. They mention that they also succeeded in artifically fertilising the eggs. According to them the cod spawn whilst swimming about freely, and the eggs are fertilised either at the surface or as they are rising to the surface.

Fulton, 1891 (31, f; p. 254), mentions that the reproductive fertility of the cod had already been studied by Buckland, Harmer, Blanchère and Earll. He himself examined three ripe females of 89—96,5 cm in length and 16—23 English pounds in weight. The longest fish had 6,652,390 eggs, the smallest 2,963,680. The same author in 1892 (31, g; p. 289) says that of 957 fish examined by him 410 were males and 547 females: 100 males to 133 females. The average length of the males was 54,3 cm, of the females 52 cm.

Of specimens landed at Grimsby none of the males under 56 cm and none of the females under 66 cm were ripe; on the other hand all above 89 cm were ripe. In this regard, the males and females shew very little difference, Holt, 1893 (49, c; p. 79).

Masterman, 1897 (67, c; p. 221), published a list of the pelagic eggs collected by the Scottish research ship "Garland" during the years 1890—96, and in this list the cod figures largely. With the aid of this material he describes the spawning places and periods of the cod, and at the same time describes the direction in which the eggs float and what their loss is after they have once become floating.

According to Hjort, 1902 (45; p. 54), the ripe cod on the coast of Finmark have a length of 65 to 80 cm.

Petersen, 1902 (80, g; p. 4), observed spawning cod in the Belts on 31st March 1900: all the larger fish were mature but those under 35,5 cm were immature.

Spawning-period: G. O. Sars first observed the floating eggs and larvae of the cod, in March 1865 (84, a; p. 27).

According to George Brook, 1886 (7, e; p. 246), March and April were the months in which the cod was observed spawning by him.

Ewart and Fulton examined 3667 cod, 1889 (24; p. 195), and came to the conclusion that the spawning time of this species extends from the end of March to May.

According to the information given by the fishery officers [Wemyss Fulton, 1890 (31, c; p. 227)] the chief spawning-period of the cod on the east coast of Scotland falls in the three months February, March and April, though spawning fish were observed from the end of January to the beginning of June. See also Wemyss Fulton, 1892 (31, g; p. 234 and Tab. VI).

Full information with regard to the time of the occurrence of cod eggs in the Firth of Forth is given by Masterman, 1897 (67, c; p. 221).

Hensen and Apstein, 1897 (40; p. 60), calculated that the spawning-period of the cod in the Baltic lasted 5 months, i. e. 20 weeks, from the 15th December to the middle of May. The maximum period occurred about the 17th February. They found that for the North Sea the spawning time lasted 6 months and that the maximum period fell about the 12th March.

Heincke and Ehrenbaum, 1900 (38; p. 244), collected cod eggs in the German Bight from the end of January to the end of March.

Hjort, 1902 (45; p. 41), found the floating eggs of cod at different places on the Norwegian coast between the 1st and 23rd April, 1901.

Spawning-regions: As early as 1890 (31, c; p. 257) Wemyss Fulton expressed the opinion that the position of the spawning regions depends upon the physical conditions, and is related to the transport of the developing eggs towards the places where the young grow up. 6272 specimens were examined by him and by means of this material he was able to say where the spawning places lay and when the maximum spawning-period occurred.

The same author, 1892 (31, g; p. 236) declares that the majority of the fish leave the coastal waters at the spawning period and move seawards to a distance of 5—20 miles from the coast. Spawning cod were observed as far as 170 miles from land.

Hensen and Apstein, 1897 (40; p. 60), found the cod eggs distributed everywhere in the North Sea. Some parts were so strongly characterized by the great numbers of eggs that they might well be called special spawning places. These authors declare however that these places are very extensive and in general must be just where the cod prefers to be. The authors "were not able to make out whether the cod periodically visits the places in shoals, or whether there are places which always again attract the cod for permanent habitation".

MASTERMAN, 1897 (67, c; p. 223), gives detailed information on the occurrence of the cod eggs in the Firth of Forth. In all probability however, the cod does not spawn there but to the east and south-east of the Isle of May.

The spawning of the cod takes place only within the coastal banks — the socalled "Fiskebanker" — and especially on the flat sand banks in depths of 54—72 m: HJORT, 1902 (45; p. 46).

PETERSEN, 1902 (80, g; p. 4), observed spawning cod in the Great Belt towards the end of March, and in the Little Belt in the beginning of April. Near Sprogö (Great Belt) on the 18th April he found amongst other eggs the floating eggs of cod.

Eggs: The floating eggs of the cod have been frequently reobserved since SARS discovered them in 1865. EARLL (20; p. 712) who in 1878 made experiments on the artificial propagation of the cod, and RYDER (83; p. 455) who published in 1884 a detailed description of the embryology, were amongst the first who confirmed the observations of SARS.

M'INTOSH and PRINCE, 1889 (72; p. 812), say that the eggs of the cod are numerous from March to May in many parts of the sea, both at the surface and the bottom. The eggs have a diameter of 1,375 mm.

FULTON, 1891 (31, f; p. 254) found in the ripe cod ovaries large perfectly clear eggs whose diameter was from 1,2—1,4 mm.

The cod eggs which HOLT, 1893 (49, d; p. 50), collected on the west coast of Ireland had an average diameter of 1,37—1,4 mm. He was able to determine without any doubt the identity of the egg, by means of the cross bands formed by the pigment which are quite characteristic of the cod larvæ.

WILLIAMSON, 1895 (98, b; p. 272), measured 92 artificially fertilised eggs and found that the diameter varied between 1,35 and 1,467 mm. He calculated the average size to be 1,386 mm.

CUNNINGHAM, 1896 (16, n; p. 283), says that the egg of the cod is very like those of the plaice and flounder, and has no oil-globule. Its diameter is 1,39 mm. According to him, the size agrees with that of the lemon dab (*Pleuronectes microcephalus*, Donovan).

HENSEN and APSTEIN, 1897 (40; p. 62) calculated from the number of cod eggs found in the North Sea in 1895 what the number of

spawning females must have been. They distinguish the various developmental stages and point out how these stages are distributed, and vary with the depth they are in.

M'Intosh and Masterman, 1897 (71; p. 238), say that the cod egg is pelagic, without oil-globule and has an average diameter of 1,386 mm.

According to Heincke and Ehrenbaum, 1900 (38; p. 243), the egg of the cod is pelagic, spherical, with delicate and closely adhering egg-capsule, without oil-globule and has a diameter of 1,23—1,6 mm (60 % of the eggs between 1,38 and 1,45 mm). Embryo has only black pigment which at first is evenly distributed, but later is collected into four zones (see Pl. II, figs. 1 and 2).

N.B. In the publication of Wemyss Fulton, 1898 (31, k; p. 88) on the growth and maturation of the ovarian eggs of Teleostei, the ovary and eggs of the cod are also treated of. For the physical and chemical changes which the eggs of certain marine fishes (also of cod) undergo during maturation, ses Milroy, 1898 (69; p. 135).

Development: G. O. Sars, 1865 (84, a; p. 27), was able to make out clearly that the embryo was outlined after 8 days, and after 18 days he had the pleasure of seeing the delicate larvæ hatching out from eggs artificially fertilised "before his own eyes". This was in March (1865) when the water was still somewhat cold.

In April the cod eggs hatch out in 8 to 10 days after fertilisation; in May the development is even more rapid; M'Intosh and Prince, 1889 (72; p. 813). The larva just hatched is about 4 mm long, has pigmented eyes, four cross-bands of pigment and a large yolk sac which is usually uppermost when the little fish is floating helpless in the water.

Canu, 1893 (12, a; 132 bis), says that the larva is 3,9 mm when newly hatched and 5,2 mm when the yolk is absorbed.

When the eggs of the cod develop in cold water, as will be the rule in nature, they require for development, 12—13 days at a temperature of 7° C. and 20 days at a temperature of 3,5° C., Cunningham, 1896 (16, n; p. 284).

In his "Contributions to the Life-history and Development of Fishes", M'Intosh, 1897 (70, g; p. 194), treats also of the cod. According to him most larvæ attain the post-larval stage at some distance from the coast, and only seek the more variable conditions of the inshore waters when they have reached a length of 1,3 to 1,9 cm, and have exchanged the surface waters for a certain depth. The larvæ of these stages are described by the author.

M'Intosh and Masterman, 1897 (71; p. 242), give figures of further stages in the development of the cod larvæ and describe the course of development in a tolerably complete manner, (see Pl. II, fig. 3—6).

According to their description, the cod larvæ whilst pelagic reach a length of about 1 cm and then move back into greater depths where they grow so quickly that they may attain a size of 2,5 cm some 5 weeks later. A young cod of 3,5 to 4,8 cm has almost assumed the form of the grown up fish but is very recognisable from its characteristic colouring: "the reversion to the transversely barred arrangement of the early larval stage".

Petersen, 1902 (80, g; p. 7), gives a good figure of a cod about six months old but does not mention the exact length (see Pl. II, fig. 8).

For the further developmental stages and rate of growth of the young cod there is a considerable amount of literature. Collett, 1875 (15; p. 105), is perhaps the first that need be mentioned. Then comes the paper of Wemyss Fulton, 1890 (31, b; p. 175), who describes the distribution of small (immature) cod near and at a distance from the Scottish coast.

The same author, 1893 (31, h; p. 195), from observations on the growth of cod which had been marked and returned to the sea, came to the conclusion that this fish grows very quickly and that the increase in growth of an average sized cod may amount to 15 to 18 cm in one year. He believes that the cod is mature in its third year.

Concerning the size of the younger and older cod which are caught and landed by the Grimsby trawlers during the various months, see Holt's paper of 1895 (49, f; p. 416). (The names used in Grimsby for the various stages of the cod are also given by him.)

In his work published in 1901 (31, l; p. 214) Wemyss Fulton treats again in detail of the cod. It need only be mentioned here that he distinguishes three stages:

A. the small cod of the first year. These are on the average 12 cm long in October and they vary between 7,5 and 19 cm.

B. the young cod which are over one year old. These are on the average 28 cm long in October, whilst they vary at that time between 20,3 and 33 cm.

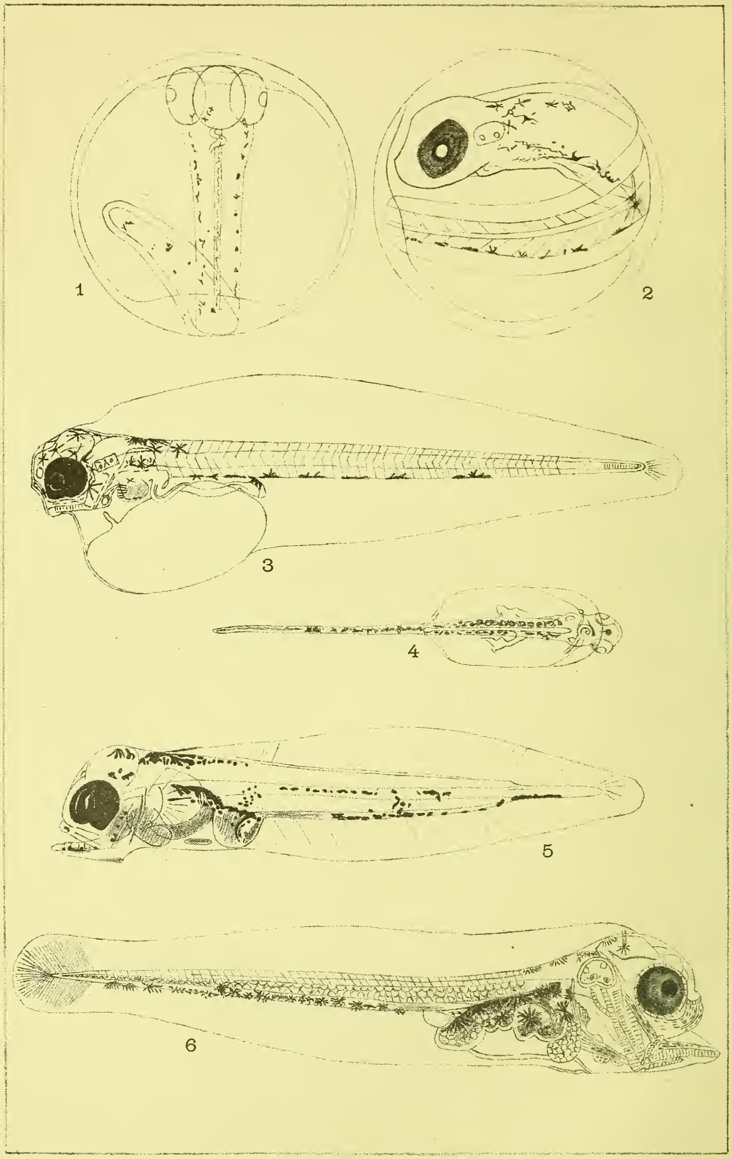
C. cod of the third year. In November their average length is 49 cm and they vary between 39 and 60 cm.

Lastly, the works of Petersen, 1902 (80, g; p. 3—25) and Hjort, 1902 (45; p. 39—60) may be mentioned. Petersen describes the occurence, rate of growth etc. of the cod in the Danish waters, Hjort its life and wanderings in those of northern Norway. As the work of the latter was carried out partly in the presence of Petersen, it is not be wondered at that their conclusions agree well and are to a certain extent complementary. On the researches carried out by them in common in the Norwegian waters, Petersen bases the following: the young fry of the cod soon after hatching, until it attains a length of 5 cm, lives during the summer months in the open sea

partly at a considerable distance from land, and not in the fjords. Great quantities of these larvæ and young fishes were caught on the surface. They form the chief nourishment of the enormous shoals of saithe (*Gadus virens,* L.) on the western coasts of Norway. On the other hand no pelagic cod larvæ were found in the whole Skagerak, neither in September 1901, nor in June. As regards the larger cod, PETERSEN ascertained further that these are very rare in the Kattegat and Skagerak in June; in September a few were taken in the eastern Kattegat and the cod fishing becomes profitable there only in November. The young of cod from 5 cm on, were found only in small numbers in the northern Kattegat and always on the bottom. The young of this size were however very numerous near the Skaw at a depth of 36 to 54 m. PETERSEN concludes from these observations, that the great mass of cod leave the Kattegat each year in summer and return there only in the colder months. From observations made at Bornholm etc. he concluded for the Baltic (in the strict sense) that the young fry of the cod do not grow there, and that this fish undertakes great migrations at different periods of the year and at different stages of its development. Their habits therefore are much the same as those of the cod of the Norwegian coast, as deseribed by G. O. SARS and by HJORT.

In conclusion it may be mentioned that HJORT in his extensive treatise (45; p. 53) distinguishes four age-groups of the cod:

0-group, composed of fish not yet one year old;
I- — small cod ("Smaatorsker") which are one year old and about 20 cm long;
II- — the so called "Finnmarkstorsker" or "Loddetorsker", fish of 2 years old, and about 50 cm long;
III- — the full grown cod "Skreier", of which the youngest are 3 years old, and about 70 cm long.



AXEL E. AAMODT KJØBENHAVN.

3. Gadus aeglefinus, L.

3. Haddock: *Gadus æglefinus*, L.

Plate III

Common Names:

Danish:	Kuller.	Dutch:	Schelvisch.
German:	Schellfisch.	Norwegian:	Hyse.
English:	Haddock.	Russian:	Pikscha, Pikschuj.
Finnish:	Kolja.	Swedish:	Kolja.
French:	Aeglefin.		

Description of the species: Good descriptions are given by Fries and Ekström (29), Kröyer (58), Günther (36), Day (18), and a short diagnosis by Möbius and Heincke (76, b).

As regards variations of the haddock Day, 1884 (18; p. 284), mentions colour-changes, and those arising from the absence of the well known black spot.

The osteology and arthrology of the haddock have been described in detail by St. John Brooks in his work published in 1884 (9).

Areal Distribution: Northerly: as far as the northern part of the Arctic Sea; at Bear Island in considerable quantities, infrequent at Spitzbergen, Ehrenbaum, 1901 (21, c; p. 108).

Easterly: in quantities on the Murman coast, and in considerable numbers in the neighbourhood of the Kanin peninsula, etc. Knipowitsch, 1902 (57; p. 593); in Skagerak and Kattegat in large quantities as far as the neighbourhood of Gothenburg. Also in Kiel Bay, but not more easterly than to the Mecklenburg coast, Möbius and Heincke, 1883 (76, b; p. 76).

EXPLANATION OF PLATE III

Fig. 1. Egg, 4th April 1898. × 33.
„ 2. Egg, 9th April 1898. × 33.
Figs. 1 and 2 from Heincke and Ehrenbaum, 1900 (38; p. 240).
„ 3. Larva just hatched. × 26,5.
From Holt, 1893 (49, d; pl. VI fig. 48).
„ 4. Larva just hatched, from the ventral aspect. × 18 ca.
From M'Intosh and Masterman, 1897 (71; pl. IX fig. 9).
„ 5. Later larva. × 17 ca.
From Holt, 1893 (49, d; pl. VI fig. 49).
„ 6. Larva of the 11th day. × 18 ca.
From M'Intosh and Masterman, 1897 (71; pl. IX fig. 10).

Southerly: as far as the Bay of Biscay and Cape Hatteras on the American coast, Day, 1884 (18; p. 286); not to the south of Cape Delaware, Brown Goode, 1884 (34; p. 224).

Westerly: as far as the American coast, e. g. abundant in Massachusetts Bay.

That this fish is very common on the west coast of Great Britain is evident from the works of Holt, 1892 (49, b; p. 307) for the west coast of Ireland, of Th. Scott, 1900 (87, c; p. 282) for the Clyde, and of Herdman and Dawson, 1902 (42; p. 47) for the coast of Lancashire. The information given by the last-named authors for Lancashire is of interest, namely, that this fish occasionally disappears for a number of years and then returns in great quantities.

The haddock is a North Sea fish in greater degree than the cod, which occurs in greatest quantities further to the north. According to the statements of the Dutch line-fishermen, the richest haddock grounds in the North Sea lie about the 54° north latitude but the best cod grounds about 57°.

Bathymetric Distribution: The best fishing grounds in the North Sea are distinguished ordinarily according as the fish are large, medium, or small. The grounds for the larger fish are in depths up to 45 m, where the bottom soil, as on the Amieland Flat, is soft and muddy, Hoogendijk, 1893 (51; p. 253). On the well known "South-west Corner" of the Dogger Bank north from the "Great Silver Pit", smaller haddock especially are taken and the depth varies here from 18 to 36 m.

In the Skagerak it lives mostly in depths from 36—45 m on muddy soil, Möbius and Heincke, 1883 (76, f; p. 76).

On the west coast of Ireland, Holt, 1892 (49, b; p. 435) obtained no haddock in depths under 18 m. Of 112 fish taken and measured by him 81 (i. e. over 72 %) were from depths of 36 to 72 m.

Food: It is a predaceous fish like the cod; since however its mouth is smaller than that of the cod — as Kröyer, 1845 (58; Vol. II, p. 58) remarks — so also its voracity is less. Its food is various according to the region. Sometimes it subsists chiefly on mollusca and worms, sometimes one finds in its stomach many crustacea, sometimes fish as herring, sand-eels and other smaller fishes.

According to Möbius and Heincke, 1883 (76, b; p. 76) the preponderance of muddwellers (mussels and ophiuroids) in the stomachs of the haddock, shows that the latter lives mostly on muddy ground.

The food of the haddock on the Scottish coasts was first studied by Brook in 1886 (7, c; p. 128). Food was found in 172 out of 200 stomachs and was constituted as follows: echinoderms, especially brittle starfish and small echinoids (*Echinocyamus pusillus*) occurred most frequently, crustacea (*Pagurus*, *Galathea*, *Hyas* and various

species of shrimps) being second in importance; then followed mollusca, young and immature forms preponderating. Worms also formed an important part of the food. Fish on the other hand occurred but seldom, with the exception of herring-spawn with which the haddock had been particularly busy in certain regions.

In a work published in 1889 (4; p. 38) Spencer F. Baird describes the mollusca which had been found in the stomachs of haddocks. He comments upon the omnivorous character of this species; the stomachs contained very numerous species of mollusca, especially such as bury themselves in the bottom-soil. Amongst crustacea *Gammarus natator* and *Crangon vulgaris* are mentioned, and of echinoderms *Psolus phantapus* and *Lophoturia Fabricii.*

In the VIIth Report of the Fishery Board for Scotland 1889, appeared the first paper by Ramsay Smith on the food of numerous fishes, amongst them the haddock. As a preliminary communication to this work the short notice by Th. Scott in 1888 (87, a; p. 230) in which the haddock is also given, may just be mentioned. The work of Ramsay Smith was carried on with the aid of the naturalists of the Fishery Board, more particularly Th. Scott, and in the years 1888—91 the food of hundreds of haddocks was studied, especially from the Firth of Forth and St. Andrews Bay. The species mentioned in their lists are very numerous; the haddock (89, d; p. 216) of all the fish studied seems to be the one, or at least one of those which are least particular in their choice of nutriment: in the Firth of Forth alone the food was composed of 70 different species of animals. These belonged, in the Firth of Forth, to the groups of crustacea (60 %), of mollusca (40 %), echinoderms (29 %) and annelids (23 %). In St. Andrews Bay the list was: crustacea (45 %), annelids (43 %), echinoderms (23 %) and mollusca (19 %). Fish and lower animals of other groups were met with in the stomachs moderately seldom: once indeed fish (herrings, sand-eels, gobies, flounder etc.) were found in 14 % of the haddocks from the Firth of Forth.

Holt's studies on the west coast of Ireland (49, b; pp. 307 and 460) gave in the main the same result. He found echinoderms in 24, annelids in 11, crustacea in 13, mollusca in 8 and a fish (*Crystallogobius*) in only one of the stomachs of the haddocks examined. The results obtained by Herdman and Andrew Scott on the Lancashire coast during their researches from 1893—95 are also in agreement with these. In 1893 (41, a; p. 16) it was found that the chief food consisted of (1) mollusca, (2) crustacea, (3) annelids and (4) echinoderms; in 1894 (41, b; p. 20) the order was (1) mollusca, (2) echinoderms, (3) annelids and (4) crustacea; in 1895 (43; p. 11) crustacea came first, then mollusca and then annelids. The numbers of fish studied (37, 52 and 32) were not however very large.

The most recent work on the food of fishes, including the haddock, is that of THOMAS SCOTT, 1902 (87,d; p. 507). The haddocks examined by him were caught south-east from the Faroes and Fair Island, and 17½% were from deep water. The fish were of various sizes but mostly small, viz. 8—14,4 and 17—23,3 cm, two only being 22 and 26,5 cm long. Their food consisted almost entirely of bottom animals, in greatest part of crustacea; in a number of stomachs pieces of annelids were also found; small molluscs, fragments of starfishes, and foraminifera were seen in only a few. SCOTT mentions no less than 83 species of crustacea which he found in the stomachs.

Reproduction: WEMYSS FULTON, 1891 (31,f; p. 255), published information over the fertility of the haddock and cites what EARLL, 1880 (20; p. 733) had said on this point. FULTON was able to examine five specimens obtained in the beginning of March, and found the largest number of eggs (806,459) in a fish of 56 cm in length and 1,81 kg in weight. On the other hand a fish of 68,6 cm and 2,95 kg had oniy 546,026 eggs. FULTON describes also the different appearances and the varying sizes of the eggs, in fishes more or less advanced in development.

The same author in 1892 (31,g; p. 232), describes the reproduction, maturity and proportion of the sexes in fishes. In the haddock the females are almost twice as numerous as the males, in the relation 188 to 100. The males however are by a little the longer, in the relation 100 to 98.

Information on these points was published about the same time by HOLT, 1892 (59,b; p. 425), for the west coast of Ireland. With the expedition of one male of 16,5 cm none of the haddock under 30,5 cm were ripe. Both sexes appear to become mature at this size "though as usual, exceptions occurred", one male of 32 cm and three females of 33 to 39 cm being unripe. For the North Sea, the same author, 1893 (49,c; p.80), is of opinion that the female haddocks begin to spawn at an average size of 33 to 35,5 cm; the smallest quite ripe specimen however, was 38 cm long. The males seem to ripen at a slightly smaller size, viz. 28 cm. All males of 30,5 cm were ripe or almost so.

In his report on the Grimsby Trawl Fishery 1895, (49,f; p.377) HOLT believes that the size at which most female haddocks spawn for the first time, is 33 cm.

HEINCKE and EHRENBAUM, 1900 (38; p. 242) give the number of eggs which tey calculated to be in two specimens of haddocks; in one of 60 cm in length and 2,3 kg. weight they found 847,768 eggs, in another of 65 cm and 2,685 kg, 1,173,480 eggs.

Spawning-period: According to Malm, 1877 (64) the haddock on the west coast of Sweden spawns from January to the beginning of March.

According to Brook, 1886 (7, e; p. 246) the months January to April form the spawning-season of the haddock on the east and west coasts of Scotland — this was not verified by himself, however.

Cossar Ewart and Fulton, 1889 (24; p. 193) say that the haddock on ihe east coast of Scotland spawns chiefly in March and April. In 1890 however, Fulton (31, c; p. 266) says that a few haddocks begin to spawn in January but that February, March and April are the chief months. Again in 1892 (31, g; p. 234) he mentions that some were still spawning in May.

On the west coast of Ireland, spawning takes place in April and May according to Holt, 1892 (49, b; p. 397). The eggs of the haddock, however, were extremely numerous in the tow nets towards the end of March.

Hensen and Apstein, 1897 (40; p. 12) have given a curve which demonstrates for the haddock, the beginning and the end of the spawning-season as well as the position of the chief period — middle of February.

Spawning-regions: The accounts of the spawning-regions are various. Cossar Ewart and Fulton, 1889 (24; p. 193), say that the haddock on the east coast of Scotland spawn chiefly at no great distance from the coast, yet beyond the territorial waters. The ripe specimens obtained in the Firth of Forth were from the stations at the entrance to the Firth. A corroborative opinion was expressed by Fulton in 1892 (31, g; p. 235); the haddocks caught within territorial waters were immature, the mature specimens seem to leave these waters in order to spawn outside.

Holt, 1892 (49, b; p. 397), on the west coast of Ireland found that the quite mature females were all taken at considerable depths, e. g. 2 at 68 m, 1 at 81 m, 3 at 126 and 144 m, and 4 at 277 m. He concluded therefrom, that the spawning of this species does not take place exclusively in the waters immediately outside the territorial limits, but that the majority spawn in all probability at considerable depths.

Masterman, 1897 (67, c; p. 225), says that "myriads" of haddock eggs are carried inwards from the outer stations of the Firth of Forth; in his opinion consequently, they are not spawned in the Forth. According to him spawning haddock were not taken more than 30 miles from the coast.

Hensen and Apstein, 1897 (40; p. 48), mention the places where haddock eggs were obtained during the three North Sea Expeditions of 1895; the maximum number was 51 eggs taken on the 18th February at the north end of the Great Fisher Bank. It was only there, and to the north and north-west of Borkum Reef that tolerably large quantities of haddock eggs were found. (See later what Heincke and Ehrenbaum say concerning these eggs).

Heincke and Ehrenbaum, 1900 (38; p. 241) examined haddock eggs which had been taken in the tow-nets N.N.W. from Horns Reef lighthouse, and others from the Great Fisher Bank. It is here not a question of myriads however (as with Masterman) but of a somewhat large number.

Eggs: Cunningham followed the development of the haddock by means of artificially fertilised eggs, and gave a description with figures of the various stages, 1885 (16, a; p. 7). According to him the size of the eggs is 1,45 mm.

M'Intosh and Prince, 1889 (72; p. 822), give 1,5 to 1,65 mm as the diameter of the egg; eggs obtained by Holt in tow-nets, 1893 (49, d; p. 51), in Valencia harbour and Clew Bay during March and April, had a diameter of 1,49 mm.

M'Intosh and Masterman, 1877 (71; p. 245), give a somewhat smaller measurement, viz. 1,458 mm.

The description of the haddock egg given by Heincke and Ehrenbaum, 1900 (38; p. 239), is the following: the eggs are pelagic, spherical, having a fragile egg-capsule and homogenous yolk without oil-globule. The diameter varies between 1,32 and 1,67 mm. The embryos in the egg have little pigment and that only black, especially on the head and in a double line along the ventral margin of the body; anus closed.

The size of the eggs obtained by Heincke and Ehrenbaum in the tow-nets, was on the average 1,5 mm in February and 1,4 mm in March. According to these authors (38; p. 242) the eggs which Hensen and Apstein, 1897 (40; p. 36) determined as haddock eggs and which were 1,6 mm when preserved in alcohol, were really those of the plaice.

N. B. Wemyss Fulton, 1898 (31, k; p. 88) describes the growth and maturation of the ovarian eggs of Teleostei, including the haddock. The physical and chemical changes undergone by the eggs of certain marine fishes (haddock, amongst the number) during the maturation of the ovaries, have been described in the same year by Milroy (69; p. 135).

Development: For the development of the egg of the haddock, the accounts of Cunningham, 1885 (16, a; p. 8) and of M'Intosh and Prince, 1889 (72; p. 822) are of special importance. The larva just hatched is figured by Cunningham, 1887 (16, b; Pl. VI, fig. 1), and Holt,

1893 (49, d; Pl. VI, fig. 48). HEINCKE and EHRENBAUM, 1900 (38; p. 239), consider HOLT's figures the best and most characteristic.

EARLL, 1880 (20; p. 730), reports upon experiments on the artificial fertilisation of eggs of haddock, which were continued from the 25nd April to June. In five days the embryo was distinctly formed but still motionless. The shortest time which the embryo required before hatching out was 8 days, the average 9 days.

According to the observations of HARALD DANNEVIG, 1895 (17, a; p. 147), which were likewise carried out in the hatchery, and whose object was to study the influence of the temperature on development, the development lasts 19 to 20 days in February, 17½ in March, 15½ in April and 13 in May.

According to M'INTOSH and MASTERMAN, 1897 (71; p. 246) artificially fertilised eggs took 20 days to hatch out on the 20th March. The larva just hatched had a length of 3,5—4,1 mm.

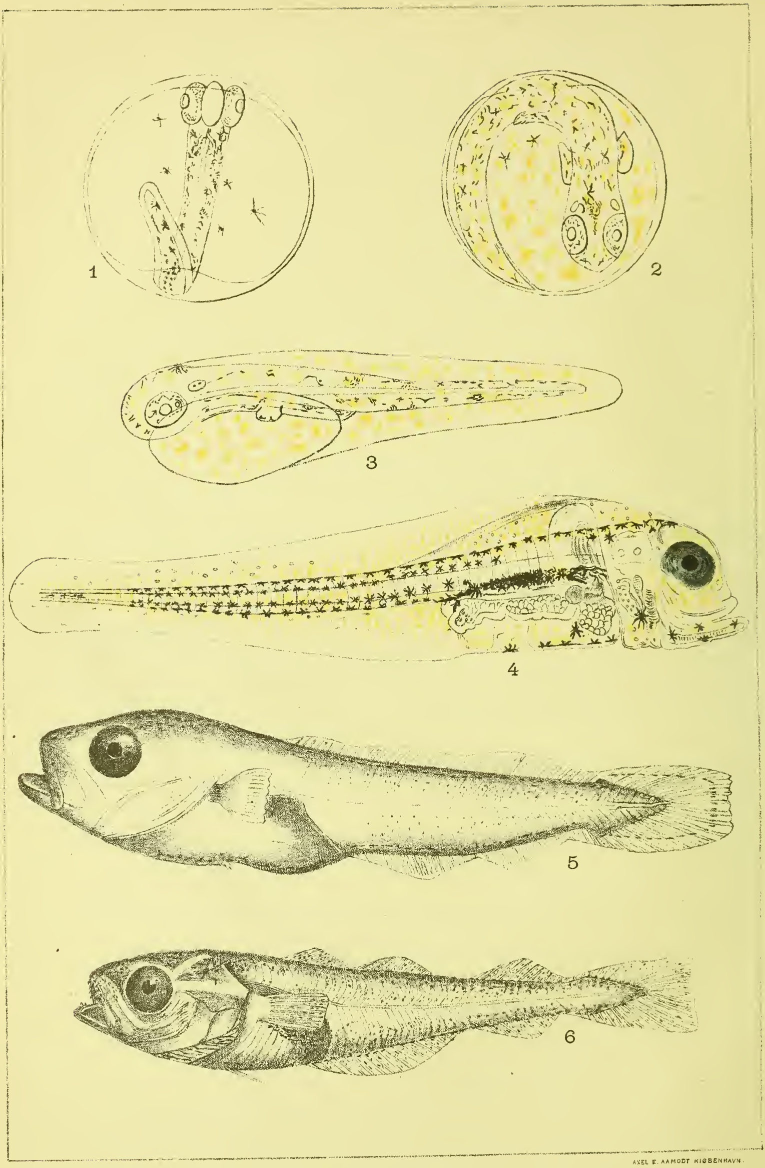
For the further development (post-larval) the accounts by M'INTOSH and MASTERMAN, 1897 (71; p. 246—251) are also very complete. These observers followed the development carefully as far as the 11th day (Pl. IX, fig. 10). The little fish have then a length of 7—8 mm. According to them the later stages have never been observed with perfect certainty, and have probably often been confused with those of the cod. On the other hand they make mention of shoals of young haddock 24—80 mm. in length, which along with shoals of young whiting were taken in the first week of July in tolerably deep water, 25 to 30 miles E. by S. from the Isle of May and in the neighbourhood of the "Long Forties". These small fishes are thus different from the young cod and saithe of the same size, in that they do not go into the shallow water in the neighbourhood of the coast. These authors describe how the small haddock from 24 to 29 mm and onwards can easily and at once be distinguished from whiting of the same size.

Metamorphosis in the young haddock takes place at a length of 39 mm; at 53 mm one can with the naked eye, detect the black spot behind the pectoral girdle.

SARS' notion, that the young haddock up to a length of 50 mm shelter under medusae, holds according to M'INTOSH and MASTERMAN, just as little for the haddock as for the cod — in Scottish waters at any rate.

Very important data concerning the development and rate of growth of the haddock are given by WEMYSS FULTON. According to him, 1902 (31, n; p. 401), the majority of the young haddock are hatched in the beginning of April, and have at that time a length of about 4 mm. Their growth is rapid; at first they are pelagic and go to the bottom only when they have attained a somewhat large size. About the end of July, the first small haddock were taken in small meshed bottom-nets; these had an average size of 108—109 mm. For the size which the young haddock reach at the end of December or beginning of January, Fulton gives 180 mm approximately. He also gives numerous data, 1901 (31,l; p. 190), with regard to the later development, and the differences in development, which exist between the young fish in the inshore waters and those in the deep water.

The papers of Fulton of 1901 and 1902 are the most recent and the most detailed which have appeared on the rate of growth of the haddock; citation from them, however, is somewhat difficult. With regard to the same subject reference may also be made to Fulton's earlier work ["The distribution of Immature Sea Fish", 1890 (31, b; p. 174)], also to Cunningham's report of 1892 ["On the probable Ages of young Fish collected in the North Sea" (16, k; p. 359)], and to Holt's North Sea Investigations, 1893 (49, c; p. 88), as also to the latter's report on the Grimsby Trawl Fishery of 1895 (49, f; p. 417).



AXEL E. AAMODT KIØBENHAVN.

4. *Gadus merlangus, L.*

4. Whiting: *Gadus merlangus*, L.

Plate IV

Common Names:

Danish:	Hvidling.	Dutch:	Wijting.
German:	Wittling.	Norwegian:	Hvitting, Hvidting.
English:	Whiting.	Russian:	Merlang.
Finnish:	Valkea turska.	Swedish:	Hvitling.
French:	Merlan.		

Description of the species: A detailed description with excellent figure is given by Fries and Ekström (29), Kröyer (58), Günther (36), Day (18); a short diagnosis is to be found in Möbius and Heincke (76,b).

Areal Distribution: Northerly: as far as the North Cape and Iceland; has not been observed further north than Iceland, nor on the American coast, Ehrenbaum (21,c). Is not found in the White Sea.

Easterly: from the North Cape has not been observed with certainty, Collett (15; p.108); is found in the Baltic as far as Gothland and on the Prussian coast often even at Hela, Möbius and Heincke (76,b; p.77).

Southerly: as far as the Bay of Biscay, and the Mediterranean where it is widely distributed if the so called *Gadus euxinus* is the same species. Steindachner, 1868 (92; p.703), considers this probable. According to Cunningham (16,n; p.290), the whiting to the south of England are larger and more numerous than in the North Sea.

EXPLANATION OF PLATE IV

Fig. 1. Tow-net egg (Heligoland). ad nat. × 33.
„ 2. The same egg on following day. × 33.
„ 3. Larva just hatched, in profile. × 25.
Fig 1—3 from Heincke und Ehrenbaum, 1900 (38; pl. IX fig. 7, 8, & 11).
„ 4. Larva, yolk absorbed. × 50.
From M'Intosh and Prince, 1889 (72; pl. XVII, fig. 12).
„ 5. Post-larval stage, length 12 mm. × 10.
„ 6. Young fish, length 25 mm. × 42.
Fig. 5—6 from Masterman, 1900 (67,d; pl. III, fig 13 & 15).

Westerly: it occurs as far as Iceland, Kröyer (58; II. p. 95), and (more to the south) on the west of Ireland, Holt (49, b).

Herdman and Dawson, 1902 (42; p. 47), say of this species that it is ordinarily very abundant in the Lancashire waters, that it is a winter-fish and is caught in the trawl mainly from December to February.

It is likewise very common in the outer parts of the Firth of Clyde, Th. Scott (87, c; p. 583).

Bathymetric Distribution: Like the other species of *Gadus* the whiting lives at all depths, Möbius and Heincke, 1883 (76, b; p. 77).

Holt, 1892 (49, b; p. 309), did not obtain the whiting on the west of Ireland at greater depths than 72 m. and Cunningham, 1896 (16, n; p. 290), says it lives more in the neigbourhood of the coast than the cod or haddock.

This holds good for the southern North Sea also — though no statement to that effect, is to be found in the literature.

According to Wollebaek, 1900 (100, p. 114), the varions age-groups of this species keep in general to different depths (in Christiania Fjord). Those of the same age form shoals and keep more together than is the case with the other gadoids. During August the 3½ year old fish are taken in the Kristiania Fjord only in depths from 36 to 72 m. In this respect Wollebaek's views are different from those of Smitt (90) and of Struxberg (93), who maintain that the whiting in autumn and winter occur only in the shallow water in the neighbourhood of the coast, and that they are never found in large shoals except at the spawning-time.

Masterman, 1900 (67, d; p. 10), gives the following "ontogenetic migration" for the young whiting: "The surface-water is forsaken at or near, the close of the larval period and the midwater is reached. A migration seawards is then effected into deep offshore waters, where the young whiting remains till a length of abont 60 mm when an inshore migration still in the midwater commences, and the littoral region is soon reached, at an average length of abont 70—80 mm".

Food: Day (18; p. 291), says of this fish; "it is a voracious feeder subsisting on small fish, crustacea and any animal substances it can obtain. Yarrell took several sprats from inside one, and Couch some pilchards. Mr Gosden found in one a female broad tailed lobster, *Scyllarus arcticus*".

According to Möbius and Heincke, 1883 (76, b; p. 77), the whiting when grown up keep mostly in deeper waters and feed there chiefly upon molluscs, crustacea, and fishes.

Duncan Matthews, 1887 (68, d; p. 317), examined the stomachs

of 400 whiting captured mostly in autumn and winter on the east coast of Scotland and found that the food of this fish consisted of young fish and crustacea. The latter consisted almost entirely of shrimps; molluscs and worms occurred only exceptionally.

Ramsay Smith (89), published several papers in the Scottish Fishery Reports for the years 1888—1891 on the food of very large numbers of whiting. From the Firth of Forth alone 1050 specimens were examined, but of these only 539 contained recognisable food. From a summary made in 1892 (89, d; p. 217), it appears that 65 % of the stomachs contained fish, 37 % crustacea, 3 % mollusca and 2 % annelids. The author remarks that there is little variation in the food of this species, which is composed chiefly of fish, herring and whiting mostly, and shrimps (*Crangon* and *Pandalus*). In 62 stomachs of whiting from St. Andrews Bay he found fish in 36, annelids in 13, and molluscs (cephalopods) in 2.

The whiting examined by Herdman, Corbin and Andrew Scott (41, a & b; p. 86) on the Lancashire coast during the years 1892—95, gave in the main the same result. The food consisted of crustacea, fish, annelids and molluscs. 116 out of 261 specimens (the largest number reported on) examined in 1894, had food in their stomachs, consisting of crustacea in 74 %, fish in 24 % and annelids in 7 %.

Thomas Scott, 1902 (87, d; p. 513), examined the food contents of 235 whiting (mostly small and sexually immature) and made a detailed report thereon. The principal nourishment of these small examples consisted of crustacea.

Reproduction: We are indebted to Wemyss Fulton, 1891 (31, f; p. 256), for the earliest information with regard to the reproductive fertility of the whiting. In a specimen of 43 cm caught in the Firth of Forth on the 24th March he found the number of eggs to be at least 150 to 200,000 eggs. Many of these were ripe and hyaline clear. Two others of 29 and 42 cm in length examined on the 8th May, contained 109,358 and 131,712 eggs respectively. More than half of the total mass of the ovary consisted of hyaline ripe eggs with a diameter of 1,14 to 1,2 mm.

Holt, 1892 (49, b; p. 420), found that the smallest mature whiting was 25,4 cm, and the largest 43 cm long. The smallest ripe male had a length ot 25,4 cm the smallest ripe female 29,2 cm. These fish were obtained on the west coast of Ireland.

For tho east coast of Scotland Fulton, 1892 (31, g; p. 236), published the information that the smallest perfectly mature male observed by him was 22,9 cm in length, and that the smallest perfectly mature female was of the same size. Fulton says at the same time that the females of this species are a little larger than the males, the relation in size being 104 : 100. The number of the females exceeds that of the males even more than is the case with the haddock; according to him there are 211 females for 100 males.

M'Intosh and Masterman, 1897 (71; p. 257), say that a ripe female may have as many as 300,000 eggs — but the females are not so much swollen as the females of the haddock; in consequence of this, the fish recover quickly and are eatable even when spawned.

Spawning period: From Brook's list of 1886 (7, c; p. 247), it appears that the spawning of the whiting on the east coast of Scotland extends from January to April, and on the west coast from February to April. These data however, were not verified by him, except that the spawning in the aquarium extends to the beginning of June.

Ewart and Fulton, 1889 (24; p. 194), observe that the spawning of the whiting extends from the end of March to the end of June. In 1890 (31, c; p. 257), Fulton states that this species spawns a little later than the haddock — from the end of March to June but chiefly in April. In 1892 (31, g; p. 232), he gives March to the middle of August with the chief period in the middle of May, as the spawning time of the whiting.

Holt, 1892 (49, b; p. 398), states that it appears from his observations on the west coast of Ireland, that the spawning period of the whiting falls in March and April, and for some fish even in June. Cunningham, 1896 (16, n; p. 291), says that in the neighbourhood of Plymouth spawning begins in February.

Canu, 1893 (12, a) mentions February and March as the chief spawning season of the whiting.

M'Intosh and Masterman, 1897 (71; p. 257), say that the spawning season on the east coast extends from March to June but falls especially in April and May, therefore distinctly later than that of the cod.

According to Masterman, 1900 (67, d; p. 9), observations made at St. Andrews and other places shew that the spawning period of the whiting extends over a very long period, from the beginning of March to the third week of August.

Heincke and Ehrenbaum, 1900 (38; p. 240), frequently found the eggs of *Gadus merlangus* in the plankton near Heligoland, during the period 28th January to the 25th May, and isolated examples on the 3rd June and 3rd July.

Spawning-regions: Cossar Ewart and Fulton, 1889 (24; p. 194), express the belief that the whiting spawn in the main, beyond territorial waters. In 1890 (31, c; p. 267), Fulton observed ripe whiting

within the territorial limit. Nevertheless in 1892 (31, g; p. 235), he again states his opinion that the majority of this species spawn beyond the territorial waters or in the neighbourhood of the limits; yet a few ripe specimens, both females and males, were found within these limits and even tolerably far up the Firth of Forth.

From HOLT's observations of 1892 (49, b; p. 339), it appears that the whiting in mature condition do not frequent the shallow waters on the west coast of Ireland.

FRIES, EKSTRÖM and SUNDEVALL, in the new edition by SMITT (29, b), assert that the whiting do not spawn in such shoals as many other species of fish, and that they seek the deeper waters for that purpose.

On the other hand M'INTOSH and MASTERMAN, 1897 (71; p. 257), say that this species does not move so far out to sea to spawn as its relatives (cod and haddock). The greatest distance from the coast at which spawning females were found was 60 miles.

MASTERMAN, 1897 (67, c; p. 225), studied the rich material of pelagic eggs which had been collected by the Scottish ship "Garland" during the years 1890—96, and came to the conclusion that the whiting, with the cod and haddock, spawns in the extra-territorial waters on the outer stations, but at a later period of the year on the stations lying inshore, with the poor cod (*Gadus minutus*) and sprat (*Clupea sprattus*).

In a later work, 1900 (67, d; p. 9), MASTERMAN says that "the whiting agrees in general with the cod in its spawning areas", so far as one can judge from the distribution of the eggs and spawning fish.

In the interval CUNNINGHAM, 1896 (16, n; p. 291), affirmed that ripe specimens were to be found at no great distance from the coast near Plymouth, and at no great depth — from two to three miles off and in 18 meters.

HEINCKE and EHRENBAUM, 1900 (38; p. 250), observed the whiting on the soft sandy and muddy grounds near Heligoland; this fish "spawns there at times on grounds which lie quite near to the coast".

Eggs: CUNNINGHAM, 1885 (16, a; p. 6), reared the eggs of whiting. These are exactly like those of the cod and haddock but smaller. Their diameter is only 1,07 to 1,25 mm. The larvæ began to hatch out on the 10th day.

M'INTOSH and PRINCE, 1889 (72; p. 824), likewise studied artificially fertilised eggs. These had a diameter of 1,23 mm, and homogeneous yolk without oil globule.

HOLT, 1893 (49, d; p. 53), who examined the eggs of this species on the west coast of Ireland, found their diameter 1,07 to 1,14 mm. In his "Marketable British Fishes", CUNNINGHAM, 1896 (16, n; p. 291), says of the whiting eggs that their diameter is 1,07 to 1,25 mm.

M'Intosh and Masterman, 1897 (71; p. 257), give the average diameter as 1,204 mm.

The most precise description of the whiting egg is given by Heincke and Ehrenbaum, 1900 (38; p. 249); yolk homogeneous without oil-globule, egg capsule fragile, diameter 1 to 1,3 mm; embryos with early appearing yellow pigment, in addition to the black which appears first on the yolk sac and the borders of the fins.

N.B. With regard to the growth and maturation of the whiting egg, see Wemyss Fulton, 1898 (31, i; p. 88); Milroy, 1898 (69; p. 135), describes also the physical and chemical changes which are gone through by the whiting egg during its development.

Development: The first information with regard to the development of the whiting egg was given by Cunningham, 1885 (16, a) and, 1889 (16, c). This was more or less completed by M'Intosh and Prince, 1889 (72) and by Holt, 1893 (49, d). For the development in the egg M'Intosh and Masterman, and Heincke and Ehrenbaum may be consulted specially.

M'Intosh and Masterman, 1897 (71; p. 257), say that the development within the egg proceeds rapidly, and that the early stages shew the gadoid characteristics. On the eighth day yellow chromatophores appear on the dorsal aspect of the larva and on the yolk sac; small yellow spots shew also on the margin of the embryonic fins. On the tenth day the little fish hatches out, and has then a length of 3,2 to 3,5 mm. It has a greenish yellow tinge which arises from the yellow pigment.

An exact description of the course of development in artificially fertilised eggs is given by Heincke and Ehrenbaum, 1900 (38; p. 250). The first signs of the yellow pigment shew after three days; on the 6th and following days the eyes begin to be pigmented; 8 days after fertilisation, the embryo extends right round the periphery of the egg. The eyes are still moderately clear, and become more or less dark only on the last day of the embryonic life. An embryo hatched from a plankton egg at Heligoland had a length of 3,2 mm.

Dannevig, 1891 (27, a; p. 149), also experimented with whiting eggs, and found that the development took 15⅓ days at 5° C, 13½ at 6°, 10¼ at 8°, 8 at 10° and 6½ days at 12° C.

Williamson, 1898 (98, c; p. 215), describes some points in the anatomy of the embryo whiting (gut, rectum, anus etc.) and gives good figures.

For the development of the larva after hatching the following papers may be specially mentioned.

M'Intosh and Prince, 1889 (72; p. 825), who were the first to give more than single details of the later development, say that

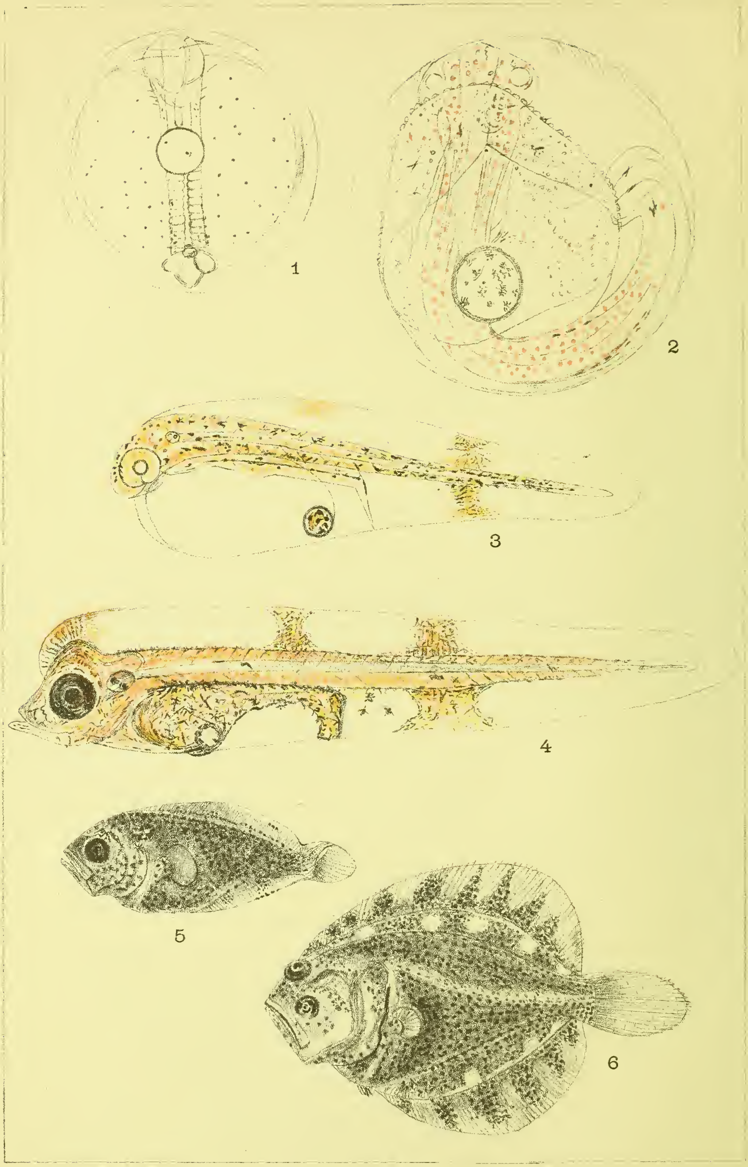
the young whiting from 15 mm onwards, can be readily distinguished from young cod of the same size since they have more strongly developed pigment, and secondly because the first anal fin is already much longer and lower.

M'Intosh, 1897 (70, g; p. 201), describes numerous early stages of the post-larval and of the young whiting. The larvæ were 9, 11, 12, 15, 20 and 32 mm in length. At a length of 45 mm the young whiting possesses well defined scales on both sides, and fine black pigment is scattered over nearly the whole surface of the body. The same author also describes the natural history of the young fish until it reaches a length of about 97 mm. The description, which M'Intosh and Masterman give of the later development of the whiting, 1897 (71; p. 259), is in perfect agreement with the description of M'Intosh. It is remarkable that according to these authors, the young whiting in the waters of the Scottish coast, have not the habit of living under and between the tentacles of jelly-fishes, e. g. *Cyanea*. On the east side of the North Sea, as mentioned by Sars, Smitt and Hjort, the young whiting of about 20 to 70 mm in length, are commonly found during the summer months along with jelly-fishes. "At Heligoland as everywhere in the open North Sea, such young whiting are never caught except in the company of jelly-fishes". (Heincke *in litteris*).

According to Cunningham, 1896 (16, n; p. 291), the larva just hatched is 3,6 mm long. According to him, the younger larval stages are with difficulty distinguished from those of the cod and haddock; the yellow pigment and the distribution of the black chromatophores over the upper and under margins of the body, are however characteristic for the whiting larvæ.

For the most detailed information with regard to the post-embryonic development of the whiting we are indebted to Masterman, 1900 (67, d: p. 9). He states that the spawning period of the whiting lasts till the middle of July, that is, not less than five months, consequently the young whiting, which are caught at any time, must shew a great difference in size. On the 11th July 1895, enormous quantities of young whiting whose length varied between 7 and 56 mm, were caught off the Firth of Forth; the majority lay between 15 and 38 mm, just as the spawning time shews a maximum period with decreasing frequency on both sides. Masterman is inclined to consider the whiting of 7 mm as only a few weeks old, and those of 56 mm as at the most five months. The earlier and later post-larval stages of the whiting are described and figured in his paper, to whick reference should be made for further details ou the development of this fish.

Lastly, it may be mentioned that the literature contains much information with regard to the rate of growth of the whiting. See Cunningham, 1891 and 1892 (16, g; p. 108 and 16, k; p. 358); Holt, 1894 and 1895 (49, c; p. 128 and 49, f; p. 377); more especially Wemyss Fulton, 1901 and 1902 (31, l; p. 185 and 31, n; p. 386). The last named author, 1890 (31, b; p. 175), also treated of the abundance of immature whiting in the Scottish waters, and in 1893 (31, h; p. 196), described the rate of growth of young whiting which had been reared in an aquarium.



AXEL E. AAMODT KIØBENHAVN.

5. *Rhombus maximus, L.*

5. Turbot: *Rhombus maximus* L.

Plate V

Common Names:

Danish:	Pigvarre.	Dutch:	Tarbot.
German:	Steinbutt.	Norwegian:	Pighvar.
English:	Turbut.	Russian:	Paltus.
Finnish:	Pükkikampela.	Swedish:	Pigghvar.
French:	Turbot.		

Description of the Species: Detailed descriptions are given by Fries and Ekström (29, b), Kröyer (58), Day (18), Günther (36). A brief diagnosis is given by Möbius und Heincke (76, b).

Holt, 1895 (49, f; p. 393), remarks that distinct structural differences exist between the turbot of Norway and those of the North Sea.

Areal Distribution: Northerly: According to Collett, 1875 (15; p. 137), probably beyond the Polar circle, though in recent times has not been observed further north than Trondhjem fjord.

Ehrenbaum, 1901 (21, c; p. 107), says that it may occasionally extend further north than the Polar circle, since it has been taken between the Lofoten Islands. It has also been mentioned as occurring on the Murman coast, but this determination has not been made by naturalists (Knipowitsch).

EXPLANATION OF PLATE V

Fig. 1. Egg. × 35.
From M'Intosh, 1894 (70, d; pl. IV, fig. 1).
„ 2. Egg seen from the ventral aspect. × 52.
From M'Intosh, 1895 (70, e; pl. VIII, fig. 9).
„ 3. Larva just hatched. × 32.
„ 4. Larva at a later stage. × 27.
Fig. 3—4 from Ehrenbaum, 1897 (21, b; pl. V, fig. 19 and 20).
„ 5. Young symmetrical turbot in pelagic stage. × 7.
„ 6. Young turbot in bottom stage. × 4.
Fig. 5—6 from Petersen, 1894 (80, c; pl. I, fig. 4 and 1).

Easterly: as far as the eastern part of the Baltic, according to Möbius and Heincke (76, b). Common in the 'Skaergaard' of Stockholm, Lilljeborg (60). Extends far into the Baltic, Petersen, 1894 (80, c; p. 42). Concerning its occurrence and distribution in the Baltic, see also Schiemenz, 1902 (85; p. 186).

Southerly: in Mediterranean including the Black Sea.

Westerly: West coast of Ireland, Holt, 1892 (49, b). On the western parts of the Atlantic or east coast of the United States, the turbot is not found.

N. B. Holt, 1895 (49, f), gives a brief account of the distribution of this species over the North Sea. Wemyss Fulton, 1890 (31, b; p. 191), states that the turbot used to be common in the Firth of Forth but is now rare. According to Th. Scott, 1900 (87, c; p. 285), it is regularly taken not far from Girvan in the Firth of Clyde. According to Herdman and Dawson, 1902 (42; p. 50), it is not rare in the Irish Sea.

Bathymetric Distribution: In the North Sea, this species is fairly common in relatively shallow water on sandy and muddy ground.

Day, 1884 (18), says that this fish "appears constantly to change its residence, migrating into deep water during cold weather similarly to the soles".

According to Holt, 1892 (49, b; p. 442), no mature turbot penetrate into quite such shallow water as some of the immature forms, and no immature forms get into such deep water as a proportion of the mature.

Cunningham, 1896 (16, n; p. 260), says of this species that it is "a shallow water fish", and that it was not obtained (by Holt) on the west coast of Ireland at greater depths than 72 m. Large specimens were often obtained in depths of 5—18 m at short distances from the coast.

Food: Kröyer, 1845 (58; Bd. II, p. 422), found five sprats in one specimen of turbot, in another some small whiting.

According to Day, 1884 (18; Vol. II, p. 13), the turbot lives chiefly on small fish, crustacea, and molluscs.

Möbius and Heincke, 1883 (76, b; p. 89), say that the turbot feeds mostly on fish but also on crustacea, molluscs, and other animals living on the bottom of the sea.

Ramsay Smith in his detailed work on the food of fishes, deals with the turbot only once, 1889 (89, a; p. 234). Of 7 specimens examined only 3 had food in their stomachs, consisting of a whiting, three small herring and one dab. One had been feeding on annelids.

Holt, 1892 (49, b; p. 463), found that on the west coast of Ireland the principal food consisted of sprats and sandeels; in single examples

were also found a dab, solenette, a species of gadoid, and a dragonet. Molluscs and worms were found in but one specimen.

According to Petersen, 1894 (80, c; p. 31), the adults of the species of *Rhombus* feed on fish, in contrast to those of *Pleuronectes* which live on lower animals.

The food of turbot caught on the south west of England was entirely fish of very various species, Cunningham, 1896 (16, n; p. 261).

According to Schiemenz, 1902 (85; p. 186) the food of the turbot in the Baltic consists substantially of fish.

Reproduction: In his paper on the reproductive fertility of fishes Wemyss Fulton, 1891 (31, f; p. 262), says that he examined five turbot; in one of 71 cm long and 7,85 kg in weight, he found 9,161,824 eggs, in another 61 cm long and 6,34 kg in weight 8,104,200 eggs; he therefore calls the turbot one of the most fertile fishes which exist.

According to Holt, 1892 (49, b; p. 420), the smallest ripe turbot which he obtained on the west coast of Ireland, had a length of 45,7 cm, the largest 63,5 cm. A male almost ripe was only 33 cm long, and a female in similar condition had a length of 57 cm. Later, in 1895 (49, f; p. 378), the same author declares that he had never met with a perfectly ripe female under 47 cm.

According to a statement of Wemyss Fulton, 1892 (31, g; p. 239), there are 68 male turbot to 134 females, or approximately 100 females to 51 males, 100 males to 197 females. According to the same author the males are smaller than the females, the average length of the males being 0,437 m, that of the females 0,516; the relation being therefore 100 to 118.

Cunningham, 1896 (16, p; p. 107), examined the maturity of turbot during May and June 1895 in the North Sea, south from Horns Reef and not far from Amrum. He found that the smallest mature male was 28 cm and the smallest mature female 35,4 cm in length.

Spawning-period: According to Möbius and Heincke, 1883 (76, b; p. 89), the spawning-period of the turbot in Kiel Bay falls in the months of May and June, and according to Malm, 1877 (64), this is also the case in the Kattegat.

Brook, 1886 (7, e; p. 250), gives a long list of the months in which the turbot spawns on the Scottish coasts — the information however, was not verified by him.

Ewart and Fulton, 1889 (24; p. 192), say that the turbot spawns in May and June, and at some distance (50—150 miles) from the coast. In 1890 (31, c; p. 265), Fulton states that 5 males and 4 females out of 50 turbot examined in May, were ripe. Two examined in the same month had spawned.

Holt, 1892 (49, b; p. 404), observed that the spawning of the turbot on the Irish coast extended from April to June, but he states that spawning perhaps occurs both earlier and later. Tow-net eggs were obtained by him in March.

On the east coast of Scotland according to Fulton, 1892 (31, g; p. 232), the spawning extends from April to July. Only in May and June, however, were ripe males and females observed.

Cunningham, 1896 (16, n; p. 261), repeats the information given by Fulton, and states that Holt's observations in Grimsby, 1892 (49, c; p. 375), lead to the same conclusions, except that some specimens were found by him still spawning in August and beginning of September.

Masterman, 1897 (67, c; p. 242), published a list of the turbot eggs caught by the s. s. "Garland" in the Firth of Forth. These eggs were caught from 19th May to 22nd July.

Heincke and Ehrenbaum, 1900 (38; p. 230), obtained the turbot eggs near Heligoland from the 19th April to the 14th August; great quantities being taken on the 25th May and 28th June.

Spawning-regions: Although we can hardly talk of places where the turbot collect together to spawn, yet there certainly are places which suit this fish for spawning better than others. These grounds seem to lie in considerable depths. Thus Ewart and Fulton, 1889 (24; p. 192), say that this fish spawns far from the coast, and Holt, 1892 (49, b; p. 404), found ripe fish (though males only) exclusively at depths from 29 to 68 m.

According to M'Intosh and Masterman, 1897 (71; p. 336), the eggs of the turbot are spawned in the offshore waters, and it is at these places also, that the larval and post-larval stages are passed through.

According to Ehrenbaum, 1897 (21, b; p. 184), the eggs and embryos of the turbot are by no means rare during the summer months in the German Bight.

The work of Heincke and Ehrenbaum, 1900 (38; 230), states the occurrence of turbot eggs in the neighbourhood of Heligoland, even as far as 20 nautical miles west of the island.

On the other hand these eggs seem to have been found extremely seldom in the British waters. M'Intosh and Masterman, 1897 (71; p. 329), remark thereon: "It is remarkable that few, if any, eggs of the turbot are found in our inshore waters, either at the surface, in midwater, or at the bottom, indeed it is one of the eggs that has hitherto escaped capture in the tow-nets of the laboratory. This may be due either to its tendency to sink — after a time — to the lower regions of the water, or to the distance of the spawning grounds".

Eggs: Information with regard to turbot eggs refer mostly to artificially fertilised eggs. A detailed historical review of the subject is given by Ehrenbaum, 1897 (21, b; p. 283). The first information with regard to ripe eggs of the turbot, came from M'Intosh and dates from the trawling expedition of the Royal Commission in 1884; then followed in 1892 the work of Holt (49, c'; p. 399), which refers to eggs taken from a ripe turbot in the North Sea and fertilised where they were found; later, that of M'Intosh (70, e; p. 223) in 1895, who stripped some turbot in the Dunbar hatchery and artificially fertilised the eggs so obtained.

Petersen, 1894 (80, c; p. 43), says that he had known the free-swimming eggs of the turbot for many years. So far as I know, however, they were not described by him.

According to Heincke and Ehrenbaum, 1900 (38; p. 230), the eggs of the turbot have a homogeneous yolk and an oil-globule of 0,148—0,220 mm. The egg-capsule has a network structure. Diameter of the egg 0,912—1,195 (0,9—1,2) mm. Embryo with finely dotted pigment black and reddish yellow at first, later bright reddish brown. Anus immediately behind the yolk sac.

According to these authors, the egg of the turbot in its earlier stages as obtained in the plankton, is easily recognised as a rule, by the diameter of the egg taken along with the diameter of the comparatively small oil-globule; the later stages by the very characteristic pigment.

N.B. For the study of the maturation of the turbot egg reference should be made to the work of Fulton, 1898 (31, i), and to that of Milroy (69) of the same year, for the physical and chemical changes in the maturing egg.

Development: Holt, 1892 (49, c'; p. 400), was probably the first to succeed in getting turbot larvæ to hatch out from artificially fertilised eggs. According to him, the development lasts ordinarily 9 days, but some larvæ begin to hatch out on the 7th day. The length of the larva just hatched is 2,14 mm, and the yolk sac takes up more than half of this length. The oil-globule has a ventral position, the marginal fins are short, the pectoral fins arise some distance from the eyes, and the whole larva is less advanced in development than is usually the case in pleuronectid larvæ just hatched. The larva has both black and coloured pigment.

Holt was able to follow the larva after hatching only a few days; soon afterwards however, he was in a position to study specimens of 5,5—16,25 mm in length, and he describes them in the same paper. All the specimens examined by him, possessed a well developed swimbladder and a short blunt snout. In the small examples the eyes are still practically symmetrical, only at 7 mm does the asymmetry become more marked. At this size the greatest height of the body without the fins, is almost a third of the body-length. The marginal fins are still very narrow. At 11 mm the greatest height is about one half the length without tail fin. In a specimen of 13,5 mm the right eye begins to shew above the edge, in the largest specimen almost the half of the right eye can be seen from the left side, and the greatest height of the body is about two-thirds of the length without tail-fin. The fin-ray formula of a small turbot of this size agrees fairly well with that of the grown up fish. Holt describes also the spinulation of the head in these young turbot.

In 1893 (80, c; p. 41 and 131), Petersen succeeded in finding large numbers of the larvæ and young ot this species born in the same year, on the coasts of the Kattegat, in the Belts and Sound, on the east coasts of Laaland and Falster, and even at Bornholm. The young were not met with till the months of June and July, but were especially numerous in August to October. The smallest observed by him was 13 mm; in October the length was 25—102 mm. Petersen afterwards described in detail the young fish of both the bottom and pelagic stages. For this last stage (18 to 20 mm in length), he described the very characteristic armature of the head — a row of spines above the left eye, another series on the gill-cover etc. and showed that this armature was absent in the bottom stages of the turbot (of 18 to 20 mm in length), and was just as little present in the later pelagic stages of the very closely allied brill (*Rhombus laevis*).

Ehrenbaum, 1897 (21, b; p. 285), describes in detail both the turbot larva just hatched, and those with the yolk almost completely absorbed, also older larvæ in the transformation stage, and the young fish of 27 mm caught on the ground. The largest of the young taken on the surface was likewise 27 mm long, yet in none of these could the metamorphosis be said to be quite complete.

Reference may also be made to the work of Cunningham, 1896 (16, n; p. 260). He paid attention to the occurrence in great numbers of the young stages of this fish, from 15 to 25 mm long, in the surface water of Sutton Pool not far from Plymouth, and describes their habits as observed in the aquarium at Plymouth. According to him, the young turbot which have quite passed through their metamorphosis are to be observed only in shallow water near the margin of the sea.

A detailed description of the development of this fish has been given (1897) by M'Intosh and Masterman (71; p. 328). These authors describe the post-larval stages and young of this species. Whilst the larval and post-larval stages live in the offshore waters, the young turbot in many cases seek "the margin, or disport themselves at the

surface, of the inshore waters". Here they remain during their youth, but as soon as they are 25—28 cm long, they seek the deeper water further from the coast.

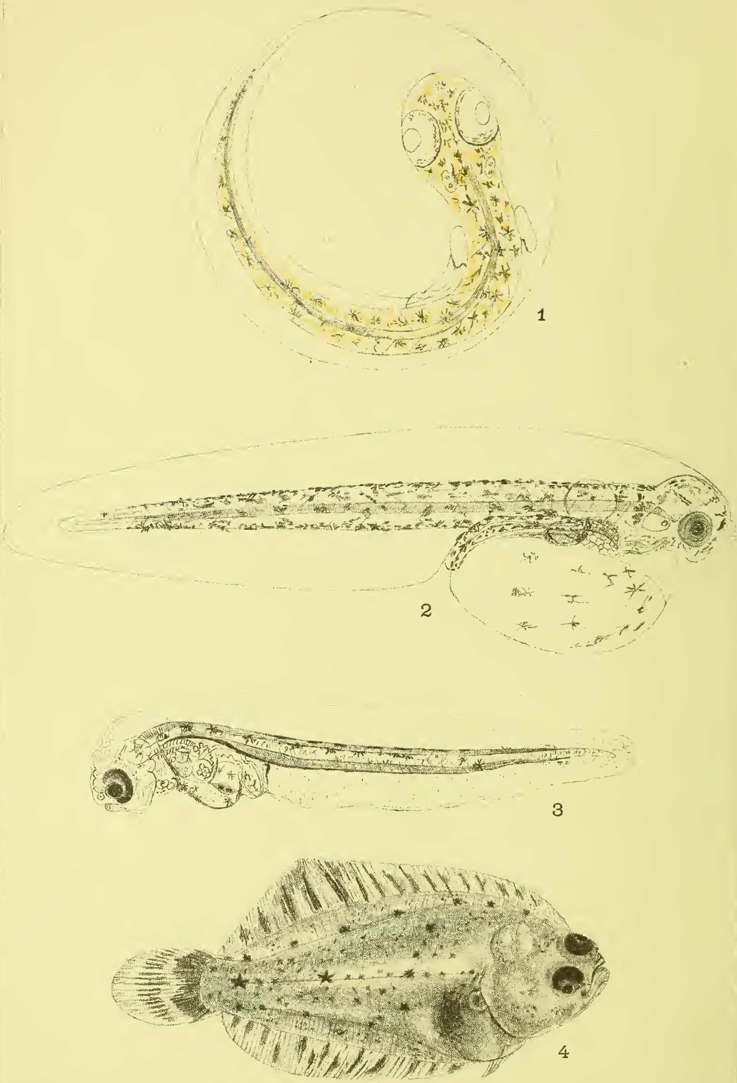
Lastly, mention may be made of some further notices — unfortunately very scarce — on the occurrence and rate of growth of the young turbot.

Fulton, 1890 (31, b; p. 171), believes that on the east coast of Scotland the great majority of the quite young turbot live on grounds distant from the coast.

On the other hand Holt, 1892 (49, b; p. 443), says that the young turbot after they have passed through the post-larval stage, make towards the coast and remain there during their first year; according to him it is only there that they have up to the present been caught.

Cunningham, 1892 (16, g; p. 105), observed the postlarval turbot to a length of 2,5 cm, swimming on the surface; the next sizes he could find were already 23 to 30,5 cm, and in all probability were 11 months old. The same author was in the position during the same year (16, k; p. 356), to examine young turbot which Holt had collected in Grimsby. These had a length of 6,8 to 38,1 cm, and were 8 months to 2 years old according to him.

A note by Fulton, 1893 (31, h; p. 195), on the increase in growth of a recaptured marked turbot is also wortly of mention.



AXEL E. AAMODT KIØBENHAVN.

6. *Pleuronectes platessa, L.*

6. Plaice: *Pleuronectes platessa*, L.

Plate VI

Common Names:

Danish:	Rødspætte.	Dutch:	Schol.
German:	Scholle, Goldbutt.	Norwegian:	Rødspætte.
English:	Plaice.	Russian:	Kambala.
Finnish:	Punakampela.	Swedish:	Rödspätta.
French:	Plie, Carrelet.		

Description of the species: Detailed descriptions are given by Fries and Ekström (29), Kröyer (58), Day (18) etc.; for a brief diagnosis, see Möbius and Heincke (76,b).

For the discrimination of the numerous species of flounders and soles which compose the family of Pleuronectidæ, the systematic work of Jordan and Goss, 1889 (56) should be consulted. A paper by Kyle, 1900 (60,d), also deals with the relationships of the flat-fishes.

A detailed summary of the literature connected with the plaice, especially for the relationships between this species and the in many respects allied *Pleuronectes flesus* L., is given by Duncker, 1896 (19). Hoek, 1890 (47,c) has also dealt with this subject in a work not cited by Duncker, on the fishes of the Zuiderzee.

Concerning the question whether various local forms (groups, varieties, races) can be distinguished within the limits of the species *P. platessa*, the works of Duncker, 1896 (19), Cunningham, 1897 (16,q), Kyle, 1899 & 1900 (60,b&c) and Petersen, 1894 (80,c) should be consulted. For the local forms in the Baltic, see also Möbius and Heincke, 1883 (76,b).

EXPLANATION OF PLATE VI

Fig. 1. Egg with embryo, artificially fertilised, from living specimen. × 32.
From Heincke and Ehrenbaum, 1900 (38; pl. IX fig. 5).
„ 2. Larva immediately after hatching. × 15.
From Ehrenbaum, 1897 (21,b; pl. IV fig. 12).
„ 3. Larva at a later stage, 12 days old. × 21.
From Fullarton, 1891 (30,a; pl. IX fig. 21).
„ 4. Young plaice, bottom stage. × 6,5.
From Petersen, 1894 (80,c; pl. II fig. 10).

N.B. A detailed description of the anatomy etc. has recently been given by Cole and Johnstone, 1902 (14).

Areal Distribution: Northerly: along the whole coast line of Norway, Collett (15; p. 144); Arctic: Murman coast, Knipowitsch (57); White Sea, Smitt (90); Iceland, Faber (25).

Easterly: in the north as far as the Behring Sea, Alaska, and Sea of Okhotsk, Smitt (90). In the Baltic as far as Gothland, Lindström (62), and also eastwards from this island in the Gulf of Finland, Fischer (28). In the Mediterranean, Giglioli (33), and Adriatic Sea, Trois (94).

Southerly: along the west coasts of Europe, possibly even further south.

Westerly: on the west coast of Ireland, Holt (49); Iceland. Common everywhere in the Irish Sea, Herdman and Dawson, 1902 (42; p. 52); tolerably common in the Clyde, Th. Scott (87, c; p. 286). Has not been observed on the east coast of America: the "Plaice" of the Americans is a species of *Paralichthys* (*P. dentatus*), according to Brown Goode (34).

Bathymetric Distribution: In the older authors, information with regard to the distribution in depth of the plaice is not abundant nor precise.

Day, 1885 (18; p. 27), says that in the Orkneys (authority, Low) this fish prefers sandy banks and muddy ground. During the summer months on the east coast of Scotland it frequents rocky ground, but in February and March it seeks sandy ground in order to spawn. It has been observed that the plaice on the coast of Cornwall prefers water of a certain depth, and approaches the coast in May. In Autumn it is found in shoals in quiet bays, but when the frost sets in, it moves back again into deeper water.

More definite and reliable are the accounts given by Holt (49, b; p. 329—339), in his "Survey of Fishing Grounds" on the west coast of Ireland. 242 stations were fished over; plaice were taken at 104 stations in depths from 0—86 metres. The greatest depth at which more than 10 specimens were caught at one time was 58 metres; at this depth, 28 plaice of 36 to 41 cm were obtained. At the other extreme, more than 10 small plaice, e. g. 19 from 3,8 to 7 cm, were taken at a depth of 1,8 to 3,6 metres.

The same author in his work of 1893 (49, d; p. 76), says that in May 1892, specimens whose size varied between 9 and about 32 mm, were captured in tow-nets attached to the beam of the trawl, or in the shrimp trawl, at depths from less than 2 to 51 metres; the majority however, occurred at less than 16 metres.

Fulton, 1893 (31, h; p. 192), described the migration of the small plaice alongshore on the east coast of Scotland. According to him, the larger plaice move offshore at the spawning-period but return after spawning.

In his report for 1893 published in 1894, Petersen (80, c; p. 14), states that small plaice under 2,5 cm never live on the bottom in deeper waters, having never found them in more than 6 metres. "Those which sink down too far from the shore must be destroyed, for no small plaice are found on the deep". In the same work Petersen gives an account of the distribution of the plaice in the Limfjord, and of his experiments on marked plaice.

Holt in 1895 (49, f; p. 398), came to the conclusion "that up to a length of about 30,5 to 38 cm the North Sea plaice is inshore or estuarine in habitat; beyond that the species nowadays at least, is practically confined to offshore grounds."

In his book on "Marketable Fishes" 1896, Cunningham (16, n; p. 216), says that adult spawning plaice are to be found in depths from 22 to 70 metres, and that none have been observed at greater depths than 90 metres.

According to Heincke, 1896 (37, b; p. 103), the plaice at Heligoland are found chiefly beyond the rocky ground at 3 to 10 miles distant, and in depths from 10 to 58 metres, on grounds which are rich in mussels; for example, on the "Pümp-grunde der tiefen Rinne" and its neigbourhood, on the Oyster Bank, etc. Young plaice of 6 to 16 cm in length are numerous on the Sandy Island (near Heligoland) in April and May.

Fulton, 1897 (31, i; p. 375), mentions that a number of plaice marked in the Firth of Forth were retaken a year or more later in the Moray Firth, at least 150 miles to the north. One was retaken to the west of the Orkney Islands "more than 200 miles from the place where it was liberated". He considers that this migration — more extensive than in the majority of cases — was due to an abnormal condition set up in the fish by the irritation caused by the marking.

Hjort and Dahl in their "Fiske-Forsög", 1900 (46; p. 138), give an account of the occurreuce of the plaice at different depths; according to them, this fish does not live at greater depths than 100 metres, and is not numerous in depths greater than about 60 metres. With exception of the eggs and the first pelagic stages, one finds all sizes of this species on the bottom, at depths between 0 and 60 metres — from the delicate quite small fish of 15 mm in its first bottom stage, to the large adult fish which may attain a size of 80 cm. The distribution of the plaice of various sizes in the Norwegian seas is also described by them, and compared with its occurrence in the southern parts of the North Sea etc.

Fulton, 1902 (31; p. 81), records the capture of plaice, in relatively small numbers, at 118 metres.

The plaice belongs to those fishes which frequent waters of low salinity in inland seas, and the strongly brackish waters of rivers. On its occurrence in the Baltic, see Möbius and Heincke, Petersen, and others. In the Zuiderzee according to Hoek (47, c), it is not rare, and it is found in the mouths of rivers according to Feddersen, 1879 (27), Seeley, 1886 (88), and Hoek, 1888 (47, a).

Food: Möbius and Heincke, 1875 (76, a; p. 313), say that they bought 12 plaice caught in a trawl in the North Sea north-west from Heligoland, and found the following animals in their stomachs: *Pelonaea corrugata, Pectinaria belgica, Sigalion idunae, Ammotrypane aulogaster* and *Amphiura filiformis.* The gut contained much mud also. The same authors in their "Fishes of the Baltic", 1883 (76, b; p. 93), say that the chief food of the plaice consists of molluscs which live in the soft grounds of deeper regions (*Tellina solidula, Corbula gibba, Scrobicularia piperita, Cardium edule*, young *Mya arenaria*), worms (especially *Pectinaria*), small crustacea (especially *Cuma Rathkii*, and sticklebacks. Seaweed may also be found in the stomachs.

Ramsay Smith in 1889—1892 (89, d; p. 212), studied the food-contents of numerous plaice. The sizes of the fish are not given, but presumably they were under 38 cm. In 1205 specimens from the Firth of Forth, 883 contained food; 54 % contained annelids, 37 % molluscs, 10 % echinoderms, 5 % fish, and 4 % crustacea. A few had eaten ascidians and one an anemone. Of 726 plaice captured in St. Andrews Bay, 509 had food in their stomachs; 59 % contained molluscs, 54 % annelids, 16 % crustacea, 10 % echinoderms, and one only contained fish. For the Firth of Forth plaice, the annelids form by far the chief nourishment, then comes *Scrobicularia*, then sand-stars and *Solen.* In the plaice of St. Andrews Bay, annelids, *Solen*, and *Nucula* form the chief food, next in importance are sand-stars, *Ampelisca*, *Portunus*, and *Scrobicularia.*

Holt, 1892 (49, b; p. 464), published an account of the food of plaice caught at 104 stations on the west coast of Ireland. His list shews that he examined 532 fishes and that lamellibranchs, annelids, echinoderms, and crustacea formed the chief contents; only a very small proportion contained fish (*Ammodytes*), tunicates (Molgula), coelenterates (*Cerianthus*) etc.

Petersen, 1894 (80, c; p. 29), states that the grown up plaice live principally on bivalves. Small plaice have a similar diet, but in plaice of the first year, under 8 cm, crustacea are most abundant.

Herdman and Scott, 1895 (43; p. 10), examined plaice of 8 to 56 cm

long, but mostly under 30 cm, and found mollusca in 72 %, annelids in 22 % and crustacea in 8 %.

In the same year Cunningham, 1895 (16, o; p. 19), published the observation that plaice had the habit of biting off the extended foot of *Solen*. Holt in 1892, (49, b; p. 464), had also found several lamellibranch siphons in the stomachs of plaice.

According to Ehrenbaum, 1897 (21, b; p. 266), the quite small plaice (of 11—12,5 mm) were living on diatoms, and slightly larger specimens on copepoda.

The observations of Th. Scott, 1902 (87, d; p. 524), are in agreement with the last; small plaice under 10 cm feed chiefly on copepoda. Schizopods, molluscs, and polychætes were also observed.

Schiemenz, 1902 (85; p. 179), says that the food of the plaice (of the Baltic) is different at different periods of life. He describes the food for the 2nd—5th year; it is composed chiefly of molluscs (*Hydrobia*, *Cardium*, *Mytilus*, *Tellina* etc.), and of *Pontoporeia*. In the 4th and 5th year, the plaice becomes predaceous and also feeds on *Ammodytes*.

Reproduction: Fulton, 1891 (31, f; p. 246), makes a comparison between the weight of the reproductive organs of the plaice and the body-weight. In 5 specimens, this relation (in round numbers) varied between 15 : 100 and 35 : 100, and the average was 25 : 100. In January he studied 5 fully developed females whose lengths were from 44 to 56 cm and weights 1,2 to 2,14 kg. The smallest and lightest plaice had about 150,000 eggs, the largest and heaviest 325,000, but the second in size 487,000 eggs.

In his "Observations on the Reproduction, Maturity, etc. of the Foodfishes" Fulton, 1892 (31, g; p. 237), says that the size of the smallest ripe male of the northern North Sea was 33 cm, the smallest ripe female observed by him 50,4 cm. The proportion of females to males is as 142 : 100, and the size as 114 : 100.

Holt, 1892 (49, c; p. 374), found that for the northern portion of the North Sea, all plaice above 43 to 44 cm were mature. In his "Survey of Fishing Grounds, West Coast of Ireland", 1892 (49, b; p. 407), he states that he examined in all 533 plaice, and that of these 262 were males, 271 females. Of these, 56 specimens — 45 males and 11 females — were mature; they were caught between March and August. He recalls that Fulton had taken nearly ripe males and females in October and November, and expresses the possibility that this species, like the herring, may have two different spawning-periods.

In the Danish waters Petersen, 1894 (80, c; p. 3), says that plaice spawn when three years old, some possibly at two years. In the Baltic, plaice of less than 20 cm were found spawning, but the average is about 25 cm. In the Lesser Belt, the average size at first maturity is 28 cm, but in the Cattegat at least 31—34 cm.

Cunningham, 1896 (16, n; p. 219), states that the smallest mature female at Plymouth was 23 cm long, the largest immature a little under 38 cm.

Reibisch, 1899 (82, a; p. 238), gives the number of eggs to be found in plaice of various sizes. He found that the fertility increased with the age. The highest number of eggs calculated was about 736,250 in a plaice of 40,5 cm in length, but several fish exceeded this size and had fewer eggs, e. g. the largest measuring 54 cm had only about 223,350 eggs. The plaice do not spawn all their eggs at one time, the highest number of ripe eggs observed in one fish being only 23,500. He also found that the absolute numbers of the large eggs in the ripe or nearly ripe plaice, could be arranged in three different groups, that these three groups were very constant, and judging from the otoliths it could be determined that they really represented three successive years growths.

In 1900 Kyle (60, c), published a paper on the average size of the plaice (both females and males) at first-maturity. The plaice of the northern portion of the North Sea as well as the southern, are dealt with, and two plates illustrate graphically the results.

In 1902 Fulton (31, n; p. 360), expresses the belief that the males of the plaice are mature when 4 years, the females when 5 years old.

Herdman and Dawson, 1902 (42; p. 52), say that the plaice of the Irish Sea is mature at a length of 33 to 38 cm (females), and 28 cm (males).

According to Schiemenz, 1902 (85; p. 181), the proportion of the Baltic plaice varies not only in different years, but is even remarkably different in separate regions.

Spawning-period: Kröyer, 1845 (58; p. 273), says that the plaice spawn early in spring but the period varies greatly according to the temperature. The ovaries are often well-developed even in December but he found them still swollen in March. In mild winters he found specimens of 40—46 cm which had partly spawned and were partly still spawning in January.

According to Möbius and Heincke, 1883 (76, b; p. 93), the spawning on the east coast of Schleswig-Holstein begins ordinarily in February and extends on to May. These authors obtained a spawning female on the 18th January 1875 and concluded therefrom that the spawning period may vary greatly under unusual temperature conditions.

Hensen, 1883 (39, a; p. 299), says that the spawning-period in the Baltic is in March and April.

Brook, 1886 (7, c; p. 242), published in the form of a table, a list

of the spawning times of the English food fishes, and for the plaice on the east coast of Scotland gives the months April and May; that is to say, the data for these months have been determined as accurate. Such is not the case, however, with the further statements that the plaice in the neigbourhood of Berwick spawn in April and May, those at Montrose in March and April, at Aberdeen February and March, Peterhead and Fraserburgh in August, and in the neighbourhood of Rothesay in March.

Fulton, 1892 (31, g; p. 242), gives a diagram which shews that the plaice on the Scottish coast are spawning from the middle of January to May, with maximum period in the beginning of March. In agreement with this, Holt, 1893 (49, d; p. 78), states that whilst January, February, and March seem to be the chief months for the west coast of Ireland, some are still spawning in April and others in August.

For the Danish waters Petersen, 1894 (80, c; p. 12), says that spawning plaice are found from November to April, but from December to March is the chief period[1]).

According to Holt, 1895 (49, c; p. 134), the spawning season at Iceland is later than in the North Sea, many fish spawning there in June. Plaice from Iceland landed at Grimsby during April, were not yet ready to spawn.

Cunningham, 1896 (16, n; p. 215), states that the spawning time in the English Channel falls in January, February, and March.

Lastly must be mentioned the recent work of Johansen, 1903 (55; p. 225), who found the plaice at Iceland with ripe eggs during June, July, and August — thus corroborating the statement of Holt.

Spawning-regions: According to Winther, 1879 (99; p. 39), the plaice round the Danish islands spawn at depths of 5,5—7 metres, but move out slowly from the spawning places into deeper water and pass the winter in 27—29 metres.

In 1890 Fulton (31, c; p. 261), expressed the opinion that the plaice do not spawn within territorial waters but some 20—25 miles offshore.

Holt, 1892 (40, b; p. 408), states that this does not hold good for the west coast of Ireland; where the declivity of the bottom is rapid, one finds near the coast similar grounds and conditions to those existing 20—25 miles off the Scottish coast, as for example, in the outer part of Ballinskelligs Bay, on the outer side of Arran Islands, and in the open portions of Donegal Bay. The depth at these places varies between

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[1]) Recently Trybom, in his paper "Trawlfiskeförsök i Östersjön", Svensk Fiskeri-Tidsskrift, 1903, p. 49, has stated that he obtained spawning plaice with the otter-trawl in the channel 50 to 100 m deep (N.E. from Bornholm) in October 1901 and November 1902.

45 and 55 metres. Holt says he has no doubt that large numbers of spawning plaice would be found there in January, February, and March.

Cunningham, 1896 (16, n; p. 215), says quite generally, that spawning plaice are found in all the deeper waters on shelly or partly shelly ground; he also cites the researches of the Scottish Fishery Board as shewing that Smith Bank, 10 to 15 miles distant from the Scottish coast at a depth of 31,5 to 36 metres, is remarkable for the very large number of plaice which spawn there during the spring.

M'Intosh and Masterman, 1897 (71; p. 357), in summing up our knowledge of the subject, say that the plaice "seldom appears to spawn within the territorial waters unless where the bottom shelves rapidly into deep water". Plaice eggs were found in quantities, along with those of the haddock, at a short distance to the east of the Isle of May and near the Bell Rock.

According to Hensen and Apstein, 1897 (40; p. 43), plaice eggs were found during the North Sea Expedition of 1895, north from the "Great Fisher Bank", on the "Long Forties", in the region between the "Long Forties" and "Dogger Bank", and at various other places.

Heincke and Ehrenbaum, 1900 (38; p. 223), say that the plaice eggs are seldom taken near Heligoland; on the 12th March 1900 however, a large quantity of plaice eggs was obtained in the plankton net 40 nautical miles N.W. from Heligoland.

Eggs: Hensen, 1883 (39, a; p. 304), in the early eighties was already calculating the size, weight, volume, and specific gravity of the plaice eggs. The average of 30 measurements gave the diameter of the egg as 1,76 by 1,72 mm, with a minimum of 1,6 and a maximum of 1,8; the specific gravity of the clean eggs taken from the ovary was calculated to be 1,01557 at 4°,5 C. Placed in salt water, these eggs had a specific gravity of 1,01496 at 6°,8 C. = 1,0136 at 17°,5 C., corresponding to a salinity of 1,78 %.

Cunningham, 1887 (16, b; p. 99), says of the plaice egg that it has a diameter of 1,96 mm, with perfectly homogenous yolk and a small perivitelline space.

M'Intosh and Prince, 1889 (72; p. 840), were able on the 21st April to examine eggs of plaice which had been artificially fertilised two days previously. The diameter was 1,65—1,7 mm, the zona radiata finely punctated and characteristically wrinkled. These authors describe also the development of these eggs.

Fullarton, 1891 (30, a; p. 311), likewise observed the wrinkled surface of the egg-capsule, and says that this makes it difficult to follow the development. He gives figures of the blastoderm cells and describes the further development.

Holt, 1893 (49, b; p. 76), obtained two plaice eggs of diameter

1,85 and 1,79 mm respectively, in the pelagic net on the west coast of Ireland.

Petersen, 1894 (80, c; p. 27), gives an account of his observations and experiments on the specific gravity and consequently, the floating capability of the plaice eggs. He found that all eggs sank in water of salinity 1,44 %, whilst the lowest salinity at which all the eggs could float was 1,85 %. Since the salinity of the Baltic water is less than this, he concludes that the eggs from other seas cannot be carried there by currents, or if so only exceptionally.

According to Cunningham, 1896 (16, n; p. 216), the size of the plaice egg varies between 1,65 and 1,95 mm. The eggs are spherical, the yolk is undivided and contains no oil-globule.

M'Intosh and Masterman, 1897 (71; p. 357), say that the average diameter of the plaice egg is about 1,79 mm. The egg-capsule shews a large number of minute punctures, and its surface in addition, is corrugated having a sheen in good light.

Ehrenbaum, 1897 (21, b; p. 260), draws attention to the great variability in the size of the plaice egg, and the consequent difficulty of relying upon this character. He had measured many eggs in different years and found the usual sizes to be 1,91, 1,94, 1,97, and 2,01, but 2,07, 2,04, 1,88, and once 1,66 were also found. The egg has no oil-globule and is quite transparent during the first stages of development; the yolk is homogeneous, the perivitelline space small, the capsule is finely punctated and so on.

Lastly, the diagnosis which Heincke and Ehrenbaum, 1900 (38; p. 223), have given for the plaice egg, may be mentioned: large egg with homogeneous yolk, without oil-globule; diameter 1,67—2,11 mm; embryo with large and bright pigment cells of black and chrom-yellow colour: anus opening immediately behind the yolk sac. According to them, the average size of the egg appears to decrease during the course of spawning, and they remark also that in some cases, the largest were found to have slightly smaller eggs on the average than smaller plaice.

Development: Hensen, 1883 (39, a; p. 300), was perhaps the first to succeed in hatching out the eggs of the plaice. He says that the larvae, which lived for 11 days, had moderately pigmented eyes, a length of 5,26 mm, large yolk sac with anus immediately behind it, and multicolumnar notochord; the gill-arches and mandible were not yet developed.

Cunningham, 1887 (16, b; p. 99), published the information that a plaice larva not yet hatched but nearly so, had a length of 4,1 mm, its eyes possessed little pigment; it had three rows of yellow chromatophores along each side and black chromatophores on the head.

The notochord was multicolumnar, the ventral fins not developed. The anus was open and lay just behind the yolk sac.

In the large treatise of M'Intosh and Prince, 1889 (72; p. 840), the development of the embryo within the egg is briefly described. The larva hatched out in 9 to 10 days and was readily distinguished from those of nearly related flat-fish by its great length. They describe the pigmentation, the very broad marginal fins and the remarkably small otoliths. Young pleuronectids from St. Andrews Bay with asymmetrical eyes as a rule, and 12 mm in length, are then described; whether these were plaice or flounders hovever, is left uncertain, since the larvae of these species when placed in spirit, could not be distinguished from one another.

Fullarton, 1891 & '92 (30, a & b), studied artificially fertilised eggs of plaice, and gave the first complete description of their development. The development in the egg lasted (January and beginning of February) 16½ to 18 days when the temperature of the water was 7° C, with a daily variation between 6° and 9° C. The absorption of the yolk took about 12 days — the entire development therefore about one month. The author gives a detailed description with numerous figures of the development during this period.

We are indebted to Holt, 1893 (49, d; p. 76), for a good description and a series of excellent figures, of the metamorphosing stages of the plaice. The specimens studied by him were caught in May 1892 and had a length of 9—32 mm. They lived at depths of less than 2. to 57,5 metres but mostly in less than 16 metres. In addition, Holt gives a summary of the lengths of the young plaice up to 100 mm long which were taken during several months. His conclusions (as to the age) agree in general with those of Cunningham, 1891 (16, g; p. 99), with respect to young plaice from 3,5 to 31,5 cm long.

With regard to the further development and growth of the plaice the question of races etc. especially of the plaice in Danish waters, we are indebted to Petersen, 1894 (80, c), for an important contribution. In this he sought to elaborate a method of determining the various agegroups. He found that the plaice of the Kattegat in their first year (November) were from 6—10 cm long. He points out also, that the period between the occurrence of the eggs in the sea and the appearance of the young on the shore is somewhat great. The two year old plaice move out from the shore and give room for the one year old, consequently the plaice grow larger as we go out from the shore[1]).

By labelling many 2 year old fish of 18—26 cm during the spring

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[1]) Compare what Hoek, 1894 (47, e; p. 332) says concerning the size of the plaice of the North Sea at different distances from the coast.

C. Apstein: "Junge Butt (Schollen, *P. platessa*) in der Ostsee."

- criticises Petersen's view.
- found the young plaice very common at Eckernfjorde in various years
  from 11 mm. to 140 mm.

- reckons the average daily growth 0.20 - 0.50 mm.
  & 1st yearly growth ca. 98 mm. on the average - max^{m} 140 mm.

in the Limfjord, he found that they grew to 33—36 cm in October and November.

From the facts:

(1) that the average size of the plaice at first maturity grows larger as we pass from the Baltic through the Belts to the Cattegat;

(2) that the young fry of less than 8 cm are found plentifully in the Cattegat but only exceptionally in the Baltic and Danish waters south of Funen and Sealand, though the fry of other species are numerous there[1]);

(3) that the eggs which occur in the Baltic do not hatch out there or only rarely;

(4) that in the Belts the 3 year old group is more numerous than the 2 year old, and that they anually appear and disappear from there (as if emigrating from the Baltic to spawn);

Petersen is disposed to believe that there is no special race of plaice in the Baltic but that "one form changes into the other already in the first generation".

In 1895 Harald Dannevig (17, a; p. 147), published a paper concerning the influence of temperature on the development of fish eggs. At a temperature of 6° C. plaice eggs required 18¼ days for their development, and eggs from the same fish took 10½ days at 12° C. In 1897 (17, c; p. 187), the same author announced that he had succeeded in rearing the plaice from the egg through the larval and metamorphosing stages until the adult form was reached. Transformation was complete in 37—48 days after hatching, 29—40 days after the yolk was absorbed.

In his book on "Marketable Marine Fishes", 1896 (16, n; p. 216), Cunningham gives a good summary of the development and metamorphosis of the plaice so far as these were then known. He also describes the natural hlstory and rate of growth of the young plaice after their metamorphosis is complete.

M'Intosh and Masterman, 1897 (71; p. 358), compare the distribution of the pigment in the embryo with that of the larva just hatched; the latter is 6 mm long according to them. This great size and the broad marginal fin are characteristic for the plaice larvae. A good review of the further development in the larval and post-larval stages. the life history of the young plaice etc. is given by these authors. They agree in the main with the views of Fulton and Petersen.

In his work on the "Eier und Larven", 1897 (21, b; p. 263),

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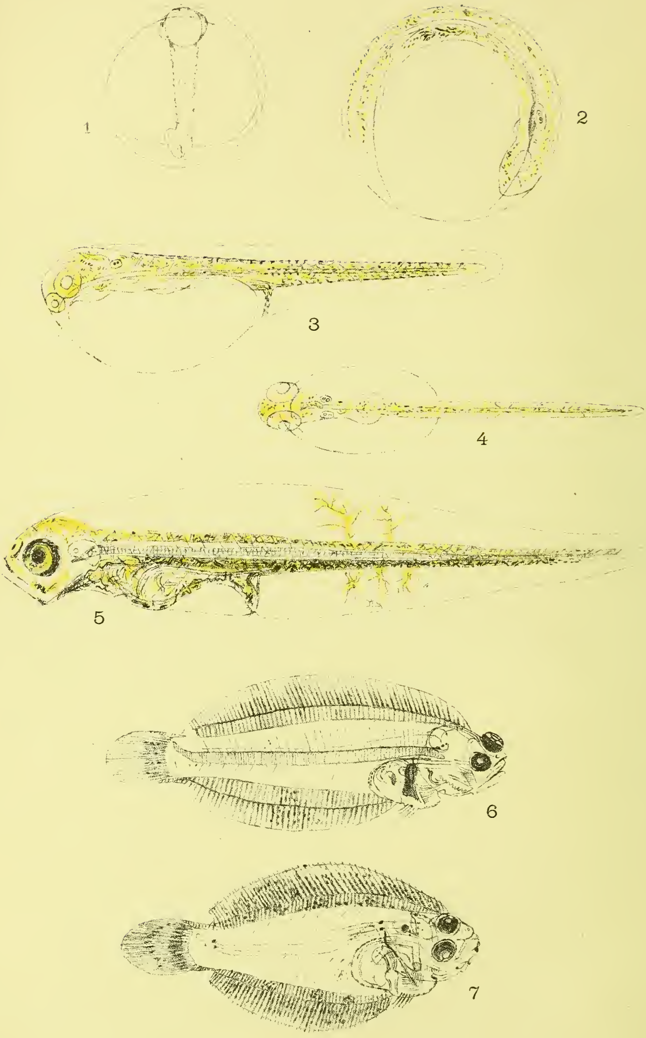
[1]) The experience of Schiemenz during the German Baltic expedition of 1901 is in agreement with this (otherwise more or less hypothetical) view of Petersen. Apart from a single plaice, 15 mm in length, from the Adlergrund, the first year's group and also the beginning of the second (up to 10 cm) were absent from the specimens obtained (85; p. 180).

EHRENBAUM treats in detail of the development of the plaice. The length of the larva on hatching was as a rule 7,5 mm. The larva is prettily pigmented and it can be seen that yellow preponderates on the dorsal aspect, black on the ventral. The yolk sac is absorbed 10—12 days after hatching. Of special importance is his observation — from a complete series of larvae — that the metamorphosing larvae and youngest stages can be distinguished from those of other species of flat-fish by means of the vertebrae, as soon as these are recognisable. This occurs when the fin-rays are only forming, and the formula for the vertebrae is as a rule 13—30. The abdominal vertebrae of the plaice amount in number to 13 as a rule, occasionally 12, in the common dab 10 seldom 11.

Young forms, about 14 mm in length, were obtained on the sandy island near Heligoland during May and June. Metamorphosis was complete in these cases, the youngest representatives of the bottom stage, but considerable variation exists, as some pelagic larvae of 15 and even 17 mm were found with metamorphosis still incomplete.

Lastly, the work of FULTON 1902 (31, n; p. 337), has to be mentioned; it is the most recent and the most detailed account of the later development and especially of the rate of growth of the plaice. The plaice of the Solway Firth (west coast of Scotland) grow on the average 60 mm during the first year, but the growth is arrested and even retrograde during the winter. On the east coast of Scotland the development is more rapid. By plotting out curves for the growth it is shewn that the females grow more rapidly than the males, that the increment of growth is greatest in the third year, viz. 80—85 mm, and that a plaice of 73—74 cm may be in its 16th year, the annual increment of growth after maturity is reached being taken to be 30 to 35 mm.



7. *Pleuronectes limanda, L.*

7. Common Dab: *Pleuronectes limanda*, L.

Plate VII

Common Names:

Danish:	Slaette.	Dutch:	Schar.
German:	Kliesche, Platen.	Norwegian:	Sandflyndre.
English:	Dab, Common dab.	Russian:	Limanda, Jörsch (Murman Coast).
Finnish:	Hietakampela.		
French:	Limande.	Swedish:	Sandskädda, Sandflundra.

Description of the Species: Detailed descriptions are given by Fries-Ekström (29, b), Kröyer (58), Day (18), Günther (36). For a brief diagnosis see Möbius and Heincke (76, b).

Areal Distribution: Northerly: on the coasts of Finmark and the White Sea as far as Schuretskaja, Malmgren (65, a); on the Murman coast and White Sea, Knipowitsch (57); well known at Iceland, Ehrenbaum (21, c); common at the Orkney and Shetland Islands, Cunningham (16, n).

Easterly: in the White Sea; in the Baltic as far as Gothland, Möbius and Heincke (76, b). West from Rügen, in moderate numbers on the Plantagenet Ground, common south-west from the Adler Ground, etc. Schiemenz, 1902 (85; p. 182).

EXPLANATION OF PLATE VII

Fig. 1. Egg with embryo, artificially fertilised; from life. × 33.
From Heincke and Ehrenbaum, 1900 (38; pl. IX, fig. 1).
„ 2. Egg with ripe embryo, of 18th March. × 42,5.
„ 3. Larva immediately on hatching. × 30.
„ 4. Similar larva, seen from above. × 25.
„ 5. Larva, 6 days old. × 30.
Fig. 2—5 from Ehrenbaum, 1897 (21, b; pl. III, fig. 1, 2, 2a and 4).
„ 6. Young Dab, 12,25 mm long, from E. W. Holt. × 5,5
„ 7. Young Dab, 15,25 mm long, from E. W. Holt. × 4.
Fig. 6—7 from M'Intosh and Masterman, 1897 (71; pl. XVI, fig. 6 and 7).

Southerly: as far as the Bay of Biscay.

Westerly: everywhere round the British Isles; was for example, taken by Holt, 1892 (49, b), at very many stations on the west of Ireland. Is absent from the coasts of North America.

Hoek, 1894 (47, a; p. 331), obtained dabs of very various sizes at all the stations in the North Sea where the trawl was used. He there pointed out how the dab differs from the plaice in that its average size does not inrease the further we go out from the coast.

Holt, 1895 (49, f; p. 399), only says of the distribution of this species in the North Sea, that it is met with everywhere and in all stages in all parts of the North Sea, both in the neighbourhood of the coast and further off. On the eastern fishing-grounds large dabs are so abundant that it is worth the trouble to bring them to market.

[According to Möbius and Heincke, 1883 (76, b; p. 97), the dab also enters brackish water and the mouths of rivers; Cunningham, 1896 (16, n; p. 223), says of this fish: "the dab has a wide range in depth and saltness of water; it is found in abundance with plaice and flounders in the lower part of estuaries though not ascending so far up as the flounder".

On the Dutch coast on the other hand, it is very rare that the dab enters brackish water. Neither in the Zuiderzee nor in the mouths of the Rhine where flounders are very common, has the dab been observed, Hoek.]

Bathymetric Distribution: Holt, 1892 (49, b; p. 344), gives for the dab a long list of places where it was taken on the west coast of Ireland: the greatest depth at which it was taken was 96 m; some were got in 65 to 70 m, 20 specimens in 63 to 51 m: but they were much more numerous in depths of 54 m and under.

The deepest places, at which Hoek, 1894 (47, e; p. 345), found the dab in the southern North Sea, had a depth of over 30 m.

According to Cunningham, 1896 (16, n; p. 223), the dab is "common in the open sea up to the depth of 90 m. It is more abundant at depths less than 63 m".

Wemyss Fulton, 1902 (31, m; p. 106), states that on the 5th November some dabs (22 and 14) were obtained in depths of 126 m south east from Girdleness.

According to Schiemenz, 1902 (85; p. 183), the dab in the Baltic prefers the banks which lie some distance from the coast. They occur also at great depths, as in the deep channel near Gotland, but they prefer shallower waters.

Food: According to Möbius and Heincke, 1883 (76, b; p. 97), the common dab of the western Baltic feeds upon crustacea, worms and molluca.

Ramsay Smith, 1891 (89, b; p. 224), examined 269 dabs from the Firth of Forth, and of these 135 were empty, only 131 containing food whose nature could be determined. In 36 were echinoderms, in 17 annelids, in 73 crustacea, in 27 mollusca, etc.; fish — herring, sprat, etc. — were found in 4. Of 86 specimens caught in St. Andrews Bay 55 had food in their stomachs, consisting of echinoderms in 17, annelids in 12, crustacea in 20 and mollusca in 9. Fish taken at other places (Moray Firth, Smith Bank etc.) showed the same food but always in some other proportion.

In 1892 (89, d; p. 213), the same author reports upon all the fish examined by him during several years: 1211 from Firth of Forth, 567 from St. Andrews Bay. In general he arrived at the same results as in previous years, but he found that in the Firth of Forth the hermit crabs formed the chief food, and next in order came annelids, then echinoderms (sand-stars) and molluscs, whilst of other animals only a few fish (*Ammodytes* and *Clupea*) were observed. The dabs from St. Andrews Bay (ibid.; p. 218) were feeding chiefly on annelids and sand-stars, secondly on *Portunus* and *Solen*, and then on *Ampelisca*.

Holt says of the dab, 1892 (49, b; p. 466), that it is a most promiscuous feeder. On the Irish coast echinoderms (especially *Amphiura* and other brittle stars) are the most important food. Crustacea (chiefly hermit crabs, but including many other forms) are of the next importance. On the other hand, annelids and lamellibranchs are much less eaten. Gastropods (chiefly *Philine*) and ascidians (*Molgula*) are only occasionally found in their stomachs, fish and squids very rarely.

According to Herdman and Andrew Scott, 1894 (43; p. 11), out of 320 stomachs examined 185 contained food, comprising annelids in 92 cases, echinoderms (chiefly *Ophioglypha*) in 39, molluscs in 38, and crustacea in 28. This work was carried on throughout the entire year; in an earlier year (41, b; p. 11) from 16th January to 29th November, the same authors found that molluscs formed the chief food, crustacea came second and annelids third in importance.

Kyle, 1898 (60, a; p. 244), examined the stomachs of 30 specimens of young dabs of 10—16 mm in length, and found the contents to be diatoms exclusively. Two had their stomachs quite full of them. The diatoms belonged to the family *Coscinodiscus* etc.

In his detailed work of 1902 (87, d; p. 526), Thomas Scott also describes the food of the dab. He enumerates 28 different species of crustacea (of which 18 were amphipods), and also many other species which he found in the stomachs of dabs: remains of fishes, lamellibranchs, *Chiton*, *Philine scabra*, annelid remains, *Echinocyamus*, *Ophiura* etc. The dabs were taken partly in Aberdeen Bay, partly in the Firth of Forth and partly in the neighbourhood of Annan.

According to SCHIEMENZ, 1902 (85: p. 183), the food of the dab in the Baltic is very varied and differs with the age. The young feed on *Mysis* and *Tellina*, at a length of 13 cm they are also feeding on *Mytilus, Hydrobia, Gammarus, Glyptonotus* etc., and above all things, fish. In middle age they also eat algoids. In the older forms the chief nourishment consists of *Glyptonotus* and fishes.

HEINCKE (*in litteris*) found from numerous investigations at Heligoland that the dab in contradistinction to the plaice, feeds chiefly on echinoderms and crustacea.

Reproduction: According to WEMYSS FULTON, 1892 (31, g; p. 239), there are 295 females to 100 males; the average length of the females was 20,75 cm that of the males 19,8 cm, so that the females are to the males in length as 103 to 100. The smallest ripe male observed by him was 15,2 cm, the smallest ripe female 14 cm. This author, 1891 (31, f; p. 265), calculated the number of eggs in a fish of 18,4 cm to be 79,194, and in a specimen of 21,6 cm 128,812.

According to M'INTOSH and MASTERMAN, 1897 (71; p. 375), the number of eggs in the common dab is less than in other flat-fish, it "is one of the least prolific of the flat-fishes".

HEINCKE and EHRENBAUM, 1900 (38; p. 215), state that the common dab spawns at a very small size (16 cm): females of this size could be used for artificial fertilisation.

In his work on the rate of growth of fishes, 1902 (31, n; p. 371), WEMYSS FULTON states that the male and female dabs grow at the same rate until a length of 16 to 17 cm is reached. The rate then diminishes for the males, whilst the females continue to grow almost as quickly as before. It results therefrom that the males are mature a year earlier than the females, namely when they are two years old, whilst the latter are three years old when they spawn for the first time.

SCHIEMENZ, 1902 (35; p. 185), says that in the Baltic the female dabs exceed in number the males in a much greater degree than is the case with the flounder and plaice. The proportion of males to females is as 1 : 1,5.

Spawning-period: COSSAR EWART and FULTON, 1889 (24; p. 190), state that the spawning of the dab in the Firth of Forth, began in May and continued to the end of June.

WEMYSS FULTON, 1899 (31, c; p. 263), declared that the spawning time of the dab extended from March to June or July, but that the chief period was probably in May.

So far as could be determined from his observations, HOLT, 1892 (49, b; p. 410), came to the following conclusions, that "spawning was

carried on during March, April and May, the number of spawning fish diminishing with each month, whilst that of the spent fish increased. Probably very little spawning takes place later than May, but the period probably commences as early as the end of February". Numbers of ripe males however, were observed even later during the course of the investigations, but Holt thinks it improbable that the milt of these is ever used in fertilisation, except in isolated cases where the spawning of a female is retarded. In all Pleuronectidæ "ripe males are found to a greater or less extent at times when there appears to be no use for them, and on this account I do not think it advisable to depend much upon the evidence of the male when considering the spawning period".

Wemyss Fulton, 1892 (31, g; p. 234), observed dabs spawning from February to July; 1,4 % of the specimens examined were spawning in February, 4,7 % in March, 12 % in April, 20,5 % in May, 13,1 % in June, 2,3 % in July: in his opinion therefore, the maximum spawning period is in the months April to June.

Canu, 1893 (12, a; p. 128), asserts that the spawning period of the dab on the French coast begins in February and lasts till the beginning of April.

Smitt, 1884 (90), says that in Sweden it extends from April to June.

According to Cunningham, 1896 (16, n; p. 224), the spawning time on the southwest coast of England falls in the months March to May.

According to M'Intosh and Masterman, 1897 (71; p. 375), the spawning time extends from March to the middle of June, and April is the chief period.

Heincke and Ehrenbaum, 1900 (38; p. 215), observed the eggs of the dab in the plankton at Heligoland during the period from the end of January (31st) to the middle of July (20th), i. e. during nearly six months.

Spawning-regions: According to Cossar Ewart and Fulton, 1889 (24; p. 190), the dab spawns chiefly in the waters near the coast; their material however was not sufficiently great for them to say if the dab also spawned in any quantity on the grounds further offshore.

In 1888 and '89 Wemyss Fulton examined 1124 dabs, of which about one third came from the Firth of Forth. From these he was able to say, 1890 (31, c; p. 263), that the dab spawns in the offshore as well as the territorial waters though chiefly in the latter. Fulton states on this occasion that the dab spawns almost everywhere. At another place in the same year (31, b; p. 170), he says that the coastal waters may be considered as nurseries for the dab but not to such an extent as for the plaice.

Holt, 1892 (49, b; p. 411), found ripe females at depths from $7^1/_2$ to 58 m; they showed no preference for any particular depth but were perhaps more frequent in shallow waters.

Wemyss Fulton, 1892 (31, g; p. 235), says that although spawning dabs were found at all stations within the territorial waters on the east coast of Scotland, they were more numerous outside those waters.

Canu, 1893 (12, a; p. 128), found the earliest eggs of the dab in depths of 18 m and over. The regions preferred for spawning were the sandy grounds met with in the neighbourhood of Boulogne s. mer, "Bassure de Baas", and especially those which lie near the Vergoyer-Bank.

Petersen, 1893 (80, b; p. 16), observed at certain times great numbers of pelagic eggs of the dab in Fänö Sound. He concludes that the spawning grounds of this fish lie not so far from the coast as those of *Pleuronectes platessa*, nevertheless they lie "outside the fresh and brackish waters where these fishes (i. e. *P. limanda* and *P. flesus*) out of the breeding-season often go in".

According to Cunningham, 1896 (16, n; p. 224), spawning dabs may be found almost everywhere, and there is no ground for the idea that this fish betakes itself to fixed places or depths during the spawning time.

M'Intosh and Masterman, 1897 (71; p. 375), agree with this statement; spawning dabs certainly occur within the territorial waters but the majority are found outside during the spawning period; considering all things, their opinion is "that the dab does not exhibit such a strongly marked migratory instinct as, for instance, the plaice".

Eggs: From the end of April onwards, Hensen (in the Baltic, in 1884?) observed small, very transparent and homogeneous eggs which he would refer to *Pleuronectes limanda*, although at an earlier period he had observed that the eggs not quite ripe had a high specific gravity (5. Bericht der Komm. z. wissen. Unt. d. d. Meere, 1887, p. 40).

According to Cunningham, 1887 (16, b; p. 100), the floating egg of the dab after the formation of the perivitelline space, has a diameter of 0,84 mm.

M'Intosh and Prince, 1889 (72; p. 837), who studied the development of the dab by means of artificially fertilised eggs, say that the diameter is 0,33 inch or "about 0,825 mm" (0,33 inch however, is 0,838) and that the perivitelline space of the egg is very small.

Holt, 1893 (49, d; p. 80), obtained in Valentia harbour the floating fertilised eggs of the dab whose diameter was 0,78—0,84 mm. He describes the egg as "spherical, with clear, colourless, and homogeneous yolk, destitute of an oil-globule, and with small perivitelline space and thin zona".

According to Canu, 1893 (12, a; p. 128), the eggs of the dab are small and spherical, the yolk is homogeneous and transparent; a perivitelline space is present but is very small; the zona radiata is smooth and the diameter of the egg varies between 0,7 and 0,75 mm.

Williamson, 1895 (98, b; p. 275), calculated the average diameter of the dab egg from 33 eggs artificially fertilised and measured, and found it to be 0,85 mm.

Ehrenbaum, 1897 (21, b; p. 268), found the diameter of artificially fertilised eggs to be 0,81 to 0,92 mm on the average, in passable agreement therefore with the English naturalists.

Heincke and Ehrenbaum, 1900 (38; p. 215), describe the egg as having homogeneous yolk without oil globule; the diameter is 0,69—0,98 mm, practically 0,7—1 mm. These authors examined both plankton and artificially fertilised eggs.

Development: Prince [1]) stated in 1886, that the dab larva was 1,7 mm long, and provided with two clear lemon-yellow pigment spots in the form of two longitudinal bands. At the end of the first week the pigment has increased and the eyes are blackish, the mouth is open but the anus still closed. Three to four days later the eyes show a greenish shimmer. The anus is open, the yolk sac is almost absorbed and the pigment is more widely distributed: in addition to the yellow pigment there are now large black chromatophores.

According to Cunningham, 1887 (16, b; p. 100), who was the first to publish a figure of the larva just hatched, depelopment within artificially fertilised eggs took only three days at a temperature of 7,5—10° C. The larva just hatched has according to him, a length of 2,66 mm, and its structure is very similar to that of other species of the same family.

M'Intosh and Prince, 1889 (72; p. 837), say that the dab eggs fertilised on the 30th April hatched ont in 12 days; when it came to the beginning of June however, and the temperature was higher, the eggs took only 7 days to hatch out. These authors inform us further, that the length of the larva just hatched is only 1,25 mm — perhaps an isolated case. They remark also upon the lemon-yellow tint of the pigmentation of the young larvæ — which in the larva of *P. flesus* is more chrom-yellow. These authors observed the post-embryonic development of the larvæ of the common dab as far as the 10th day; a few days later all the larvæ died.

According to Canu, 1893 (12, a; p. 129), the eggs of the dab hatch out in 10 to 15 days according to the temperature. The small stretched-out larvæ have black chromatophores and others, which are of a pretty lemon-yellow. In their other characters the larvæ shew the characteristics of Pleuronectid larvæ. At first they are 2,6 mm in length; when the yolk after about 10 days, is absorbed, the larvæ have a length of 3,5 mm.

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[1]) Prince, E. E., Early Stages in the Development of the Food Fishes. *Ann. Mag. of Nat. History,* May 1886.

Ehrenbaum, 1897 (21, b; p. 268), in agreement with M'Intosh and Masterman, found that the larva of the common dab hatched out in 7 days at a temperature varying between 7 and 10° C.; he states that the larva just hatched had a length of 2,67 mm; this measurement is in agreement with Cunningham's, whose statement however, that the development of the dab egg took place in three days, Ehrenbaum considers is due to some error. The latter followed the further development of the larvæ until they were 13 days old; on the 6th day the yolk sac was absorbed more or less completely, and the entire length of the larva was 3,8 mm. On the 10th day the length was very little greater, about 4 mm; in the 13th day larvæ the pectoral fins were distinctly larger, and so on. Ehrenbaum makes special comment on the very delicate, and faint black and yellow pigment of the dab larvæ.

According to Heincke and Ehrenbaum, 1900 (38; p. 215), the embryo of the dab is provided with finely dotted black and lemon-yellow pigment, and has the anus opening immediately behind the yolk sac.

For the later developmental stages and the natural history of the young dabs reference should be made to the works of Petersen, Holt and Kyle. Petersen, 1893 (80, b; p. 16), was able to obtain very few young dabs under 51 mm long. The smallest which he observed living on the bottom was about 32 mm — a single example of which, found in September, he considered to be 4 months old. The young fish about 1 year old, which he found about the spawning time i. e. in June, were from 64 to 89 mm long. The fish which were at that time 2 years old, were 127 to 178 mm. The larger of these had so far advanced in development in September and November that one could see, even though the development ceased from December to March, that they would take part in the spawning during the next season: they are thus fish in their third year.

The young of the dab of various years groups were often found by Petersen on the same grounds. As soon as the pelagic stage is passed through, the young dabs live in deeper water than is the case for example, with the young of the plaice and flounder. Wherever they are found, one finds all the various age-groups at the same place, with exception oniy of the grown up specimens which are often found singly.

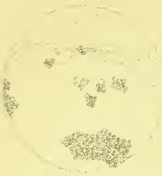
In the work published in 1894 Petersen (80, c; p. 126) informs us that the smallest dabs he had recognised, were taken in November and were 12—13 mm long. On the same occasion Petersen says, that their size agrees with that of the largest which still lead a pelagic life

and that the dab therefore, though smaller than the plaice and flounder, reaches a greater size whilst still pelagic than these pleuronectid allies.

Holt, 1893 (49, d; p. 80—83, fig. 112—115), gives good drawings and a detailed description of young dabs from 12,25—16 mm, which he obtained in a pelagic net made fast to the trawl. He is of the opinion that these stages represent the metamorphosis during three months.

Kyle, 1898 (60, a; p. 228), was in a position to examine a rich collection of post-larval dabs, plaice, flounders etc. and to compare these forms with one another. He especially studied the differences between post-larval plaice and dabs, and describes these for the small fish below 9 mm, of 9 to 15 mm and of those more than 15 mm long. A table of characteristics and 13 figures of the dab from 5 to 16,5 mm in length, are included in his work.

Lastly, with regard to the rate of growth of the dab, reference should be made to the papers of Cunningham, 1892 (16, g; p. 100 and 16, h; p. 228), of Williamson, 1893 (98, a; p. 265), and more especially to that of Wemyss Fulton, 1902 (31, n; p. 360—372). From the last mentioned work the following brief summary may be taken (p. 370): the average length of the dab when one year old, would be 6,7 cm.; in the second year it reaches a length of about 14 cm, and at the conclusion of its third year it has a length of about 22 cm.



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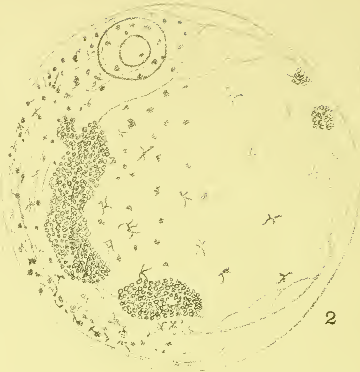

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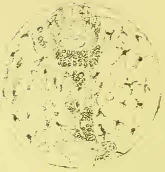

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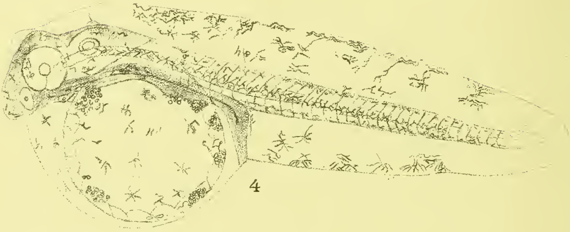

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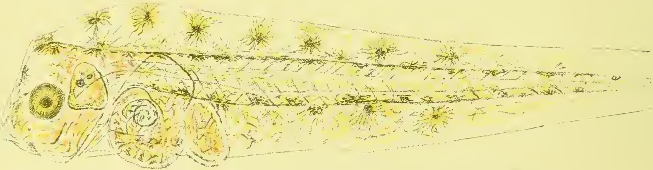

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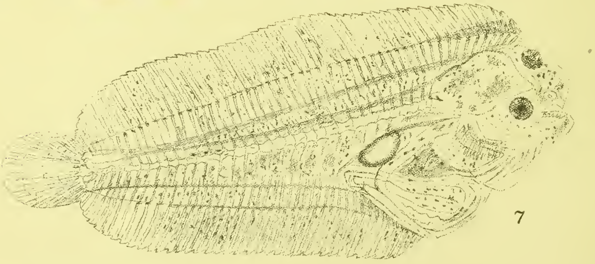

7

AXEL E. AAMODT KJØBENHAVN

8. Solea vulgaris, Quens.

8. Sole: *Solea vulgaris*, Quensel.

Plate VIII

Common Names:

Danish: Tunge.
German: Seezunge.
English: Common Sole.
Finnish: Kielekampela.
French: Sole.
Dutch: Tong.
Norwegian: Tunge.
Russian: Sol, Jasyk.
Swedish: Såla.

Description of the Species: Fries and Ekström (29), give a good description with fine figure, also Kröyer (58), Günther (36), Day (18); a brief diagnosis is given by Möbius and Heincke (76, b). A monograph on the structure, natural history, etc. of this species is given by Cunningham in his "Treatise", 1890 (16, e).

Areal Distribution: Northerly: according to Collett (15), Conservator Storm observed many specimens in Trondhjemfjord (64° N. Lat.); in general, this fish occurs but sparingly on the south and west coast of Norway. Has been observed at the Faroes by Landt, but very rarely, Kröyer (58). Is absent from the Arctic waters. According to Cunningham, 1896 (16, n; p. 249), it seldom occurs north of the latitude of the Firth of Forth, but M'Intosh and Masterman, 1897 (71; p. 388)

EXPLANATION OF PLATE VIII

Fig. 1. Egg, lateral view. × 23.
From M'Intosh and Masterman, 1897 (71; pl. IV fig. 9).
„ 2. Egg, from living specimen. × 42.
From Cunningham, 1896 (16, n; fig. 114).
„ 3. Egg in later stage, pigmented yolk. × 23.
From M'Intosh and Masterman, 1897 (71; pl. IV fig. 10).
„ 4. Larva, just hatched, from living specimen. × 27.
From Cunningham, 1896 (16, n; fig. 115).
„ 5. Larva at a later stage, after the absorption of the yolk sac. × 28.
From Ehrenbaum, 1897 (21, b; pl. V fig. 30).
„ 6. Common Sole in transformation stage, from life. × 9.
From Cunningham, 1896 (16, n; fig. 117).

declare that the sole is found in many of the sandy bays on the east coast of Scotland and by no means rarely.

In his work on the Grimsby Trawl Fishery, 1895 (49, f; S. 393), Holt makes the following remarks on the distribution and occurrence of the sole in the North Sea: "The species is very rare in Scotch waters, but occurs more plentifully southwards along the east coast of England. It is found also on the grounds lying off the coast of Denmark, and southwards along the continental margin, also in the central parts of the North Sea, south of a line which may be drawn across so as to follow the southern edge of the Dogger Bank. Thus the Dogger and all the central area of the North Sea northwards of this bank may be eliminated as practically devoid of soles. None are found, I believe, on the coast of Norway."

Easterly; in the entrance to the Baltic it is not common, has not been observed in the Baltic further to the east. Is only seldom in isolated instances taken in the western Baltic as far as the Mecklenburg coast, Möbius and Heincke, 1883 (76, b; p. 100).

Southerly: as far as the Mediterranean.

Westerly: west coasts of Europe (Möbius and Heincke), on the west coast of Ireland, Holt, 1892 (49, b; p. 355). Is absent from the coasts of North America, as Brown Goode, 1884 (34; p. 175), remarks: "it does not occur in the western Atlantic."

Bathymetric Distribution: According to Day (18, Vol. II, p. 40), the sole on the English coast withdraws into deep water "as frost sets in, revisiting the shallows about May if the weather is warm, their migrations being influenced by temperature."

According to Cunningham, 1896 (16, n; p. 249), the sole is exclusively a "shoal water fish". The richest grounds for this fish in the English Channel as in the North Sea, lie according to him, at a depth of 5 to 40 fathoms; that is, from 9 to 70 metres.

It has been shown by Holt, 1892 (49, b; p. 413), that ripe soles may occur at all depths between 4 and nearly 60 fathoms (7 to nearly 110 metres), whilst the unripe do not seem to go beyond 30 fathoms (55 metres). He declares however, that speaking generally, the ordinary resort of this fish on the English coast is in more or less shallow water and in the neighbourhood of the coast, whilst he believes it probable that this is one of the fishes which (partly) move out into deeper water at the spawning-time.

In his "Examination of the present state of the Grimsby Trawl Fishery", 1895 (49, f; p. 393), Holt gives a short account of the distribution of the sole in the North Sea; after the completion of their first metamorphosis the sole is an estuarine or at least an entirely littoral form until it has reached a size which closely agrees with that at

which it becomes sexually ripe. "Of the winter habitat of young soles it is hard to speak positively, since very few can be obtained anywhere. To a certain extent they may migrate into deep water, but I know no proof of this, and I am inclined to share the belief of many fishermen that they hibernate to a great extent by burying themselves in the sand."

Holt speaks afterwards also concerning the presence of large adult soles in the "Silver Pits".

According to Herdman and Dawson, 1902 (42; p. 55), numerous sole grounds lie within and in the neighbourhood of the "Lancashire and Western Seas Fisheries District", and extend from its northern to its southern limits. Soles are caught there throughout the whole year; in the warmer months they come to the neighbourhood of the coast and are numerous in mouths of rivers and bays, in the colder months they move out from the coast into deeper water.

Food: According to Möbius and Heincke, 1883 (76, b; p. 100), the sole feeds chiefly on Molluscs (*Solen pellucidus*, *Cyprina islandica*, *Scrobicularia alba*), worms, and crustacea (*Cuma Rathkii*).

From Holt's work on the fishes of the west coast of Ireland, 1892 (49, b; p. 466), it appears that annelids formed the chief nutriment of the soles living there, that brittle starfishes and other echinoderms were second in importance, crustacea (*Gammarida, Crangon* etc.) third, whilst mollusca (chiefly small *Solen* and *Philine*) and fish are of still less importance.

Herdman and Andr. Scott in 1895 (43; p. 15), give an account of the food in the stomachs of over 151 soles; 122 were empty or their contents were unrecognisable; in the remaining 29 they found annelids in 18, crustacea in 10, and mollusca in only one.

In his book on "Marketable Fishes", Cunningham, 1896 (16, n; p. 249), says that of 36 soles which had food in their stomachs, 18 were feeding on worms, 9 on echinoderms (mostly star fish), and 4 on crustacea. In the aquarium the soles prefer worms, but feed also on shrimps, pieces of fish or molluscs etc.

The same author publishes in his "North Sea Investigations" of 1895 (16, p; p. 124), a description of the food which he found in the stomachs of quite small soles caught in the neighbourhood of Lowestoft. The contents of the stomachs consisted entirely of crustacea with a certain proportion of sand. The smallest of these soles was only 38 mm long; larger examples of 12,5 to 23,5 cm had merely the tail ends of *Arenicola* in their stomachs.

Th. Scott, 1902 (87, d; p. 528), found annelids and lamellibranchs in the stomachs of soles caught in the Clyde, and in those from Annan likewise annelids with a small proportion of crustacea.

Reproduction: Holt, 1892 (49, b; p. 412), examined 414 specimens on the west coast of Ireland and found that 245 of these were females and 169 males. The largest sole, approaching ripeness, had a length of 48 cm, the smallest 25,4 cm. The largest ripe sole was 46 cm long, the smallest 29 cm. The smallest male which he observed as nearly ripe was 25,4 cm, the smallest female in similar condition was 30,5 cm. The smallest quite ripe male was 29 cm, the smallest ripe female 35,5 cm. Holt further remarks upon the small size of the male sexual organ in the sole.

Butler, 1895 (10; p. 3), gives a few data concerning the act of spawning in the sole which he was able to observe in the aquarium of the Marine Station at Plymouth.

Cunningham, 1896 (16, n; p. 251), says that the relation of the numbers of the male and female soles and the relation of the sizes in the different sexes have not been so closely studied as is the case with other species. It may be taken as a well determined fact, however, that the females are not only more numerous, but also larger than the males. The same author declares that a sole of one pound weight i. e. 454 gram, has been estimated to have 134,000 eggs.

Herdman and Dawson, 1902 (42; p. 55), say that the smallest ripe female sole observed by them was 28,6 cm long, the smallest ripe male, 25,4 cm. According to them the sole produces 100,000 eggs.

Spawning-period: According to Möbius and Heincke, 1883 (76, b; p. 100), the spawning time of the sole falls in the months of May and June; according to them, the soles on the English coasts have ripe spawn in them already at the end of February.

In their treatise of 1889 M'Intosh and Prince (72; p. 848), say that a sole with ripe eggs was observed by them on the 1st August 1884, and that these eggs, although no ripe male was to be found and they could not be fertilised, floated on the surface. Floating (and fertilised) eggs were first obtained on the 6th July (188?). At a later period they were also obtained in the middle or end of May. The spawning period on the east coast of Scotland lasts therefore from May to August.

Holt, 1892 (49, b; p. 412), on the west coast of Ireland observed soles which were nearly ripe as well as quite ripe fish of both sexes in March to June, and further found a ripe female in August. He met with spawned fish in the same months, but their number became greater from March to May, and in June and the following months they were also numerous.

In the Mediterranean, Marion, 1894 (66), succeeded in obtaining the pelagic eggs of the sole already in February.

Heincke, 1894 (37, b; p. 104), in his work on the Fishes of Heligoland says that soles spawn in May and June.

Butler, 1895 (10; p. 3), first observed the fertilised eggs of the sole in the neighbourhood of Plymouth on the 12th April, and again from the 20th and 21st April onwards with a short break till the 16th May. He also made some observations on the period of the day at which spawning took place; the fish spawned earlier in the day when the weather was warmer.

Cunningham, 1896 (16, n; p. 251), says that the spawning time on the coast of Devon and Cornwall extends from the middle of February to the middle of May, and that the sole was observed spawning in the North Sea from the end of April to the end of July.

According to M'Intosh and Masterman, 1897 (71; p. 387), the spawning time for the east coast of Scotland extends from the middle of April to the beginning of August. The eggs shew themselves first in St. Andrews Bay, and the entire spawning time lasts about 4 months.

The period at which Heincke and Ehrenbaum, 1900 (38; p. 236), caught sole eggs in the plankton from the neighbourhood of Heligoland, lay between the 27th April and 7th July. These authors, taking account also of the data from the east coast of Scotland, say that the months of April to August may be taken as the spawning time of the sole in the North Sea.

According to Herdman and Dawson, 1902 (42; p. 55), the sole in the Lancashire District spawns from March to June.

Spawning-regions: The accounts of the spawning-regions in the literature of the sole are neither very numerous nor very definite.

Holt, 1892 (49, b; p. 413), says that he found a certain number of spawning females at almost every depth at which he took ripe specimens. He believes however, that the presence of very large quantities of such ripe fish in the outer portion of Ballinskelligs Bay (west coast of Ireland) at a depth of 47 to 49 metres is connected with the process of reproduction. No unripe specimens were obtained amongst them and very few had spawned, whilst the greater number were ripe or nearly so. It appears to him probable therefore, that some soles spawn at their ordinary habitats, as in Blacksod Bay, whilst others betake themselves into deeper water for this purpose, or at least undertake migrations in one or the other direction. From the distribution of the ripe females as observed by him, he comes to the conclusion that the distribution of the spawning fish agrees with that of the mature specimens.

In his work on the Grimsby Trawl Fishery, 1895 (49, f; p. 393), Holt says that the spawning of the sole on the English coasts takes place chiefly on the offshore grounds, always in water of a certain depth, and distant from the places where the young fish mostly live. On the eastern side according to him, spawning takes place in greater proportion on the grounds where the small fish live.

Cunningham, 1896 (16, n; p. 251), says that the spawning of the sole takes place in the deeper water; e. g. on the south-west coast of England, beyond the Eddystone and south from the Wolf Rock, at a certain distance from the coast of Cornwall, and in Mount's Bay, in depths from 37 to 73 metres.

During the three voyages of the North Sea Expedition carried out between 14th February and 1st May, 1895, by the "Deutschen Seefischerei-Verein", no sole eggs were observed — which is to be ascribed probably to the fact that the spawning period of the sole in the North Sea begins later in the year. The quantitative measurement of the eggs obtained during these expeditions was carried out by Hensen and Apstein, 1897 (40; p. 31).

Herdman and Dawson, 1902 (42; p. 55), say quite generally that the spawning grounds of the sole lie at some distance from the coast.

Eggs: Ripe eggs were observed in 1884 probably for the first time, by M'Intosh on the east coast of Scotland. They were however unfertilised eggs (72; p. 848).

In 1888 Raffaele (81), published figures of the developing eggs of two species of *Solea* to which *S. vulgaris* is indeed nearly related (Ehrenbaum), yet they cannot be taken as identical with this species without further research.

In their treatise of 1888 (1889) M'Intosh and Prince (72; p. 849), give a brief description with a figure of the sole egg, and remark upon the presence of the groups of very small oil-globules which have a yellow colour by reflected light.

Cunningham, 1889 (16, c; p. 17), gives a more detailed description of the structure and development of the sole egg. According to him, the diameter of the egg is 1,47 to 1,51 mm. The eggs have two characteristics: (1) they shew a great number of extremely small oil-globules in place of the ordinary large one, (2) the yolk is not perfectly uniform and homogeneous, but its superficial layer is divided up into yolk-segments co-extensive with the blastoderm.

The same author describes the characters of the sole egg in his "Treatise on the Sole", 1890 (16, e), and in his book on "Marketable Fishes" of 1896 (16, n; p. 251).

Holt, 1893 (49, d; p. 92), mentions the important difference in the size of the sole eggs. He found that ripe eggs taken from a female and afterwards artificially fertilised were on the average from 1,43 to

1,49 mm, whilst a plankton egg had a diameter of 1,58 mm. He describes the structure of the eggs and agrees in the main with his predecessors.

M'Intosh and Masterman, 1897 (71; p. 388), give a tolerably detailed description of the sole egg and say that the diameter measures from 1,143 to 1,295 mm. The size of the small oil globules was also determined by them.

Ehrenbaum's description of 1897 (21, b; p. 308), agrees in the main with those of the above mentioned authors. He mentions that the eggs of the sole are remarkable for the very small and numerous oil-globules collected together in characteristically formed groups, also that the surface of the yolk shews a more or less vesicular or segmented structure.

Holt, 1899 (49, h; p. 84), reasoning from his observations on the eggs of the sole on the west coast of Ireland, considers it possible that the soles found there like those of the English Channel produce larger eggs on the average than those of the Scottish east coast and German Bight. He believes that the races which produce the larger eggs have likewise a higher average body-length.

Lastly, the following diagnosis which Heincke and Ehrenbaum, 1900 (38; p. 236), give for the eggs of the sole, may be mentioned:

"Eggs with segmented outer zone of the yolk and with several groups of innummerable, very small oil-globules. Diameter of the egg in the North Sea 1,0 to 1,38 mm, in other seas as high as 1,58 mm".

The remarkable difference between the data of various naturalists with regard to the size of the sole egg is further discussed by these authors.

Development: The embryological as well as the post-embryological development of the sole has been repeatedly and closely studied, and may be considered as well known in regard to the chief points.

In 1868 Malm (64), published a short description and some figures of the metamorphosis of this fish, and in 1888 our knowledge of its development was further advanced by the researches of Raffaele (81). Thereafter various treatises on this subject have rapidly followed one another.

M'Intosh and Prince in 1889 (72; p. 849), describe the earliest developmental stages for the soles of the Scottish coast, obtained from eggs and larvæ reared in the aquarium. They were able to follow the development until the larvæ were nearly 10 days old. A larva of 5 mm long obtained in St. Andrews Bay on the 22nd August and belonging in all probability to this species, was described and figured by M'Intosh in the VIIth Report of the Scottish Fishery Board, 1889, part III (p. 304, pl. III, fig. 4).

In the same year CUNNINGHAM (16, c; p. 18), published a short description of the developmental stages in eggs which he had succeeded in fertilising artificially. The eggs came from fish caught in the neighbourhood of Plymouth and were similar to some taken in the pelagic nets. The same author in his "Treatise on the Common Sole" gave a detailed description of the early stages of the sole — larva immediately after hatching, as well as older larvæ and young stages — and to these he was able in 1891 (16, f; p. 68), to add the descriptions of larvæ 4 and 6 days old reared in the aquarium, and of an older larva caught in Plymouth Sound. In 1892 appeared, also from his hand, a description with figure of a *Solea*-larva 11 mm long, caught in the neighbourhood of Plymouth (16, i; p. 327, pl. XIV, fig. 2).

CANU, 1893 (12, a; p. 132 bis), published a description and good figures of eggs and larvæ of the sole obtained in the neighbourhood of Boulogne-s.-mer; and HOLT, 1893 (49, d; pl. VIII, fig. 65), gave a fine figure of a larva about 3 days old hatched from an egg which he had taken in the pelagic net. From his description it appears that the larva just hatched has a length of about 3,3 mm, and that the colour of the pigment of the larva is pale dark yellow by reflected, and black by transmitted light.

BUTLER, 1895 (10; p. 3), says that eggs spawned on the 28th April hatched out in 7 days, but that a week later they only took 5 days to hatch. During the development of these latter eggs the temperature was higher, viz. 13° to 14° C.

To CUNNINGHAM, 1896 (16, n; p. 251), and M'INTOSH and MASTERMAN, 1897 (71; p. 388), we are indebted for detailed summaries and descriptions of the developmental history of this fish, founded for the most part on their own observations. CUNNINGHAM says that the larva hatched out in 10 days at a temperature of 9° to 10° C. and had a length of 3,5 to 3,7 mm. M'INTOSH and MASTERMAN say that the eggs of the sole develop rather slowly, and that the larva just escaped from the egg-capsule has a length of about 3 mm.

In 1897 EHRENBAUM (21, b; p. 310), gave a review of the larval stages, the metamorphosis, etc. of the sole. He found the length of the larva just hatched to be 3,21 mm, and its appearance exactly as figured by CUNNINGHAM, M'INTOSH, and HOLT. He has given a good figure for the conclusion of the process of the absorption of the yolk, and has described in detail the young soles reared from the eggs. He also remarked on the scarcity of older stages in the open waters as well as on the even greater rarity of the larvae at the period of metamorphosis.

In February and March 1901 FABRE-DOMERGUE and EUGÈNE BIÉTRIX (26), succeeded in rearing the larvae of the sole from eggs obtained

in the plankton[1]). The larvae began to feed long before their yolk had been quite absorbed. A few days after the yolk sac had disappeared they began to chase animals (larvae of sprat, flounder, medusae, etc.) which had about the same size as themselves. The small soles during their pelagic life are great hunters and very greedy. For a period of about 6 to 8 weeks the soles remain quite symmetrical and attain a length of 10 to 11 mm; the change into the form of the adult takes place rapidly and is complete within a few days. These authors succeeded in rearing the young soles until they had reached a length of 35 mm.

HERDMAN and DAWSON, 1902 (42; p. 55), say that the larvae of the sole hatch out in about 10 days.

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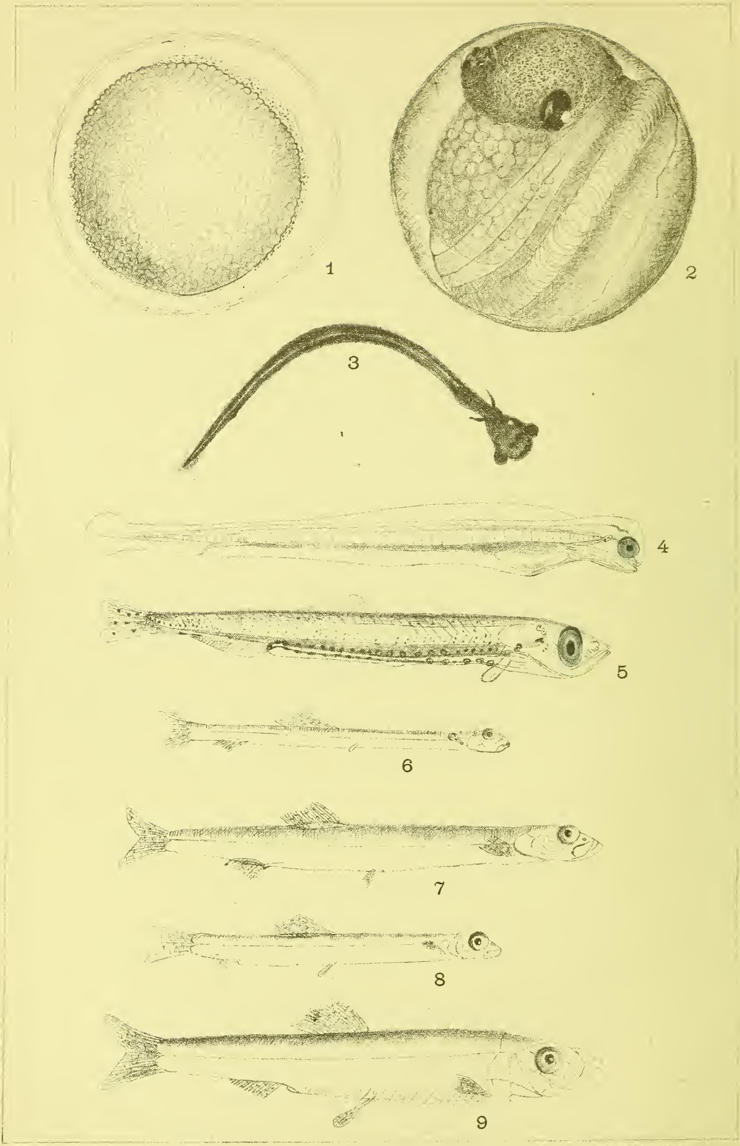
[1] Vide also CANU's remarks on the artificial rearing of the sole, 1893 (12, a; p. 132 bis). He speaks of it as: "pisc culture aisée et indispensable".



AXEL D. ARNDDT KJØBENHAVN

9. *Clupea harengus, L.*

9. **Herring:** *Clupea harengus*, L.

Plate IX

Common Names:

Danish:	Sild.	Dutch:	Haring.
German:	Hering.	Norwegian:	Sild.
English:	Herring.	Russian:	Silakka, Haili.
Finnish:	Sseldj, Sseledka.	Swedish:	Sill.
French:	Hareng.		

Description of the species: See Fries and Ekström (29), Kröyer (58), Günther (36), Day (18); and for a brief diagnosis Möbius and Heincke (76, b).

It is generally accepted that all the herring of the North of Europe form one single species, but that they appear as very different local forms (subdivisions, varieties, races). In the furthering of our knowledge of these races, concerning the divisions of which however no complete agreement exists, the following have rendered important service: the Scandinavian naturalists Nilsson (79), Boeck (5), G. O. Sars (84, b) and Ljungman (63); also Duncan Matthews (68, a) and Hoek (47, b), but the most important is Heincke (37, a & c). In Heincke's last work, 1878 (37, c) a critical survey is made over the literature

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EXPLANATION OF PLATE IX

Fig. 1. Egg after fertilisation. × 33.
From Brook, 1886 (7, b; pl. I, fig. 2).
„ 2. Egg with developed embryo on the 6th day. × 40.
„ 3. Larva just hatched from dorsal aspect. × 40.
Fig. 2 and 3 from Kupffer, 1878 (59, b; pl. IV, fig. 45 and pl. III, fig. 36).
„ 4. Larva in bottom stage. × 16.
„ 5. Larva further developed, littoral stage. × 3,2.
Fig. 4 and 5 from M'Intosh and Masterman, 1897 (71; pl. XIX, fig. 2 and 5).
„ 6. Young herring from the saltwater of Eckernförde Bay; autumn herring. × 2.
„ 7. Similar form, still in larval condition, but further developed. × 2.
„ 8. Young herring from the brackish water of the Schley; spring hering. × 2.
„ 9. Young herring, in adult form, from the brackish water of the Schley. × 2.
Fig. 6—9 from Heincke, 1898 (37, c; p. 20, fig. 1).

connected with the subject. The works of Heincke (from 1878—1898), make it possible to distinguish with certainty the separate varieties and local races of the herring, by applying the mathematical method of treating variations to numerous characteristics and to their combination.

Areal Distribution: Northerly: to the furthest North of Norway, on the Murman coast and the White Sea; at Greenland (Davis Strait); and Iceland, etc. It is probable according to the information given by Malmgren, 1865 (65, b), that the herring occurs at Spitzbergen, although it does not seem to have been caught there as yet.

Easterly: has been observed in the White Sea and on the north coast of Asia as far as the mouths of the Obi and Jenisei, also in the neighbourhood of Kamtschatka and Japan. In the Baltic as far as the Gulf of Finland.

Southerly: in the Bay of Biscay (has not been observed in the Mediterranean).

Westerly: as far as the western side of the Atlantic Ocean: on the coast of America from Cape Hatteras as far as the northern part of Labrador and Greenland.

Bathymetric Distribution: For the older ideas concerning the haunts of the herring under the extensive icefields of the Arctic Ocean and so on, see Johan Anderson, 1746 (3). In 1832 Nilsson (79, a), had already definitely stated that there were different varieties or races of the herring, and that they ordinarily remained in the open sea not far from the coast, which they visited in order to spawn.

Boeck (5), considers it probable that when the herring is not in the neighbourhood of the coasts it is to be found in great depths of the sea. According to him, fragments of deep sea crustacea which he found in the stomachs of herring, indicate that it really dwells in deep water when it is not in the neighbourhood of the coast. He is of the same opinion as Nilsson, viz. that it does not undertake great journeys but seeks out deeper places near the coast where it spawns.

Möbius and Heincke, 1883 (76, b; p. 172), say that the herring of the Baltic is a dweller in the surface layers, and that it comes in shoals to spawn on the shallow algal-covered coastal regions, particularly the brackish water bays.

According to Collett 1875 (15), the researches of Boeck and Sars show that the herring is a pelagic fish whose habitat is in the open sea along a great stretch of the Norwegian coast. At certain times however, it seeks the land in part for reproduction, in part for food.

G. O. Sars (84, b), opposes with good reason the theory of Boeck that the herring apart from the spawning time lives in the depths of the open sea.

Ljungman, 1878 (63, a), gave a clear review and critical summary of the data, many of them resting on the experience of many generations of fishermen, concerning the influence of different physical conditions on the movements of the herring. Though of some worth such data are all more or less in the air, since they are not based on systematic research [Heincke, 1898 (37, c; p. 53)].

According to Heincke, 1898 (37, c; p. 45), the herring is an 'apertikolous' fish, that is, one which frequents the upper layers of the open sea and changes from its apertikolous mode of life (a) at the spawning-season, (b) when it is living in narrow coastal waters and seeks for food on the shallow, sandy or (alga) covered grounds of the littoral zone. "In the open sea at great distances from the land, the herring seems to go down very rarely to the bottom of the ocean. Otherwise greater quantities would be taken more frequently in the trawl."

The idea expressed by Murray (78), some years ago that the herring has its feeding grounds in deep water and that it returns there after the completion of spawning, which occurs in the neighhourhood of the coast, has not yet been confirmed by direct observation.

Hjort in his work which appeared in 1902 (45), makes some remarks on the scattered appearance of the herring in the northern parts of the Atlantic Ocean; the difficulty is to determine whether the deep water layers contain herring, since only the upper few fathoms of the sea can be exploited by drift-nets.

Though not directly connected with the bathymetric distribution, a recent treatise dealing with the dependency of the herring on the hydrographical conditions may be briefly referred to.

In the works of the older Scandinavian naturalists, Ljungman, Widegren, etc. the idea repeatedly occurs that certain places visited by the herring are shunned by them for a longer or shorter period. What happened on the Bohuslän coast especially gave countenance to this idea. The failure of the winter fishing in 1896/97 was closely studied by a group of naturalists (the hydrographers G. Ekman and O. Pettersson, the plankton-investigators P. T. Cleve, Aurivillius, and Hjort) and these, as shewn in their work published at Gothenburg in 1897 (13), came to the conclusion that the reasons for the failure were to be found in the physical and biological conditions existing at that time in the Skagerak. According to Ekman and Pettersson the herring, which forms the mainstay of the winter fishing at Bohuslän, is connected invariably on its appearance near the Bohuslän coast with the so-called bankwater, and appears and disappears with it. This bankwater is North Sea water of 32—33 per mille salinity which arises from the mixture of the continental waters with the ocean water entering from the north. The failure of the herring fishery in the autumn of 1896 arose from this, that the much fresher water of the Baltic covered almost the entire surface of the Skagerak in quite an abnormal manner.

In his latest work, 1898, Heincke (37, c), discusses and in great part accepts the ideas of the Swedish hydrographers. He employs the name 'bank-herring' for the autumn herring of the eastern North Sea, of the Skagerak, the Kattegat, the western and middle portion of eastern Baltic as far as Gothland, and on the other hand classes the spring herring of the Baltic and of the east coast of the Skagerak as herring races of the Baltic stream. The spring herring of the Bohuslänfjords come entirely under the influence of the weakly saline and at this season, cold Baltic stream. The autumn or 'bank-herring', and these spring herring, or herring of the Baltic stream, can be distinguished from one another according to Heincke, by certain body characters, by habitat, mode of life, spawning-period and so on. Each of the two groups divides up again into different local races.

Food: In his essay on herrring-"aat", Axel Boeck, 1866 (5, a), made an important contribution to our knowledge of the food of the herring, and the best of the older literature is here referred to. "Rödham" or "Rödaat" according to Boeck, consist exclusively of copepods of the families *Calanus, Eikocalanus (Temora?), Centropages* and *Anomalocera.* "Gul-aat" is made up according to him, partly of transparent copepods, partly of annelid larvæ (*Leucodore ciliata*), whilst "Svartaat" or "Krustaat" consists chiefly of young specimens of snails of the genus *Rissoa.* Later works of Boeck, especially "Om Silden og Sildefiskerierne" which appeared in 1871 (5, c), as well as the contribution of G. O. Sars 1871 (84, b), should be consulted on this matter.

Möbius, 1878 (75), informs us that copepods form the chief nutriment of the herring in the western part of the Baltic; the herring finds this food in all strata from surface to the bottom. The larger crustacea, it must seek for in the region of the living seaweed, the worms, mostly in somewhat deeper water in the region of the dead seaweed. The information given by H. A. Meyer, 1878 (73, b), on the development of the herring, and by Möbius and Heincke, 1883 (76, b; p. 138), on the food of the Baltic herring in general, agrees with the conclusions of Möbius.

Brook and Calderwood, 1886 (8; p. 102), published an account of the food of the herring, the most important results in which are that the chief food of the herring on the east coast of Scotland is quite different from that on the west coast, and that the chief feeding periods on the two coasts fall in quite different periods of the year. The work of Thomas Scott in 1888 (87, a; p. 225), agrees with this;

in about 43 % of the herring studied by him schizopods, especially *Nyctiphanes* formed the chief mass of the food, and this both in the stomachs of the winter herring and in those caught in the middle of summer. Of amphipods, *Parathemisto* seldom appeared in the stomachs of the herrings of the east coast, never in those of the west. Copepods formed an important part of the food of the herring caught in Loch Fyne, but were found in only 4 stomachs of herring caught on the east coast. In a number of herring sent from Stornoway he found some small fish. SCOTT came to the conclusion that, with exception of the Loch Fyne herring, schizopods played a no less important part than the copepods in the food of the herring.

In 1890[1]), HENSEN published his views on the occurrence of plankton in the eastern Baltic and on the occurrence of the herring in the same regions. Herring live mostly on the copepods and daphnids of the plankton, and probably find rich nourishment only in those places where these crustacea congregate together in masses like small clouds.

During the ten year period, 1888—98, few works specially on the food of the herring were published. In 1898, HEINCKE (37, c; p. 42), in his great work shews that the food has also to do with the question of the division of the herring into local forms: a right description of the mode of life of the herring can only come from a series of separate descriptions of each and every local form. The only thing that holds good for all, is that the food consists of the chief animals in the plankton, especially those which are distributed over certain areas in great numbers such as copepods and schizopods.

In 1902 THOMAS SCOTT (87, d; p. 529), published the result of fresh researches on numerous but almost entirely small and immature herring of the east coast of Scotland, without however bringing much to light that was new. Copepods formed the chief food; only in one sample of 31 herring caught in December in Aberdeen Bay was the chief portion of the food composed of an amphipod (*Parathemisto oblivia*) along with *Sagitta.*

Reproduction: According to WIDEGREN, 1870 (97), the spawning-process of the herring is performed very rapidly, since the spawning shoals are on the ground probably only 5 to 6 hours. The spawn falls on seaweed, stones, sand, and such like, and remains there.

LJUNGMAN, (1874) 1878 (63, a), mentions the older and newer views on the age of the herring when they first spawn (from NILSSON, EKSTRÖM, SUNDEVALL, WIDEGREN, AXEL BOECK, and G. O. SARS). His own observations are concerned specially with the spawning time of the socalled small herring on the coast of Sweden (see Spawning-period). In a later work 1879 (63, b), he gave a general summary of the spawning-process in the herring.

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[1]) 6. Bericht der Kommission zur wissenschaftl. Untersuch. d. deutschen Meere in Kiel. XVII—XXI. 1893. p. 107.

Kupffer, 1878 (59, a), describes the spawning of the herring in the western Baltic; according to him, these fish are very wild and restless during spawning.

Cossar Ewart, 1884 (22, a; p. 66), who observed the herring during spawning on the Ballantrae Bank and made control experiments in the aquarium, describes the behaviour of the fish whilst shedding its eggs, during the process of fertilisation and so on. According to him, a higher temperature accelerates the spawning; the males remain longer on the spawning-places than the females, because they require a longer time to get rid of their sexual products. A ripe herring caught on the 29th March was 33 cm long and had a weight of 0,34 kilo.

According to Hoek, 1890 (47, c; p. 236), the ripe herring of the Zuiderzee have a length of 24—27 cm, and a weight of 110—143 gram. The weight of the ovary is 23—27 gram.

According to Wemyss Fulton, 1891 (31, f; p. 267), the number of the eggs in the ripe herring varies between 21,503 and 47,466. In 16 herring examined by him, the average size being 28.6 cm, the average number of eggs in the ovaries was 31,768. These were herring caught in January to March on the east coast of Scotland (Dunbar, Wick, Firth of Forth).

Wemyss Fulton, 1892 (31, g; p. 239), informs us on the authority of the Scottish fisheries inspectors that there are 1774 males to 1782 females (99 to 100). He had no data however with regard to the size of the ripe fish, which size in any case could be determined only for herring of a certain race or form and not for the herring in general. According to Fulton, the average weight of the ovaries of 16 herring whose average length was 28,5 cm, was 35 gm; on the other hand, the average weight of the testes in 10 herring of the same length was 35,6 gm.

According to Heincke, 1898 (37, c; p. 46), the ripe sexual products of the herring cannot be pressed out all at one time; the duration of the individual spawning amounts in any case to several days perhaps one to two weeks. The spawning of a shoal extends mostly over two or three months in his opinion. It also seems as if the larger fish of a shoal spawned earlier than the smaller. A higher temperature may accelerate the spawning.

Numerous opinions have been expressed with regard to the age at which the herring reproduces for the first time, especially by the older Scandinavian naturalists. In the Report of 1863, Huxley expresses the opinion that the herring becomes ripe in one year. In a speech of 1881 (53), however, he declared that he had overrated

the rapidity of development and that he agreed with Mitchell and Yarrell that the herring reached its fully development in eighteen months. According to Meyer, 1878 (73, b; p. 241), the herring of Kiel Bay attain a length of 130 to 140 mm in their first year, from 160 to 175 mm in their second year, and spawn only in their third year. Jenkins (54), determined in 1902 the age of herring in Kiel Bay by examination of the otoliths and came to the same conclusions as Meyer. Heincke says nothing definite on this point; he considers it possible, however, that the age at first maturity varies in different regions. On the other hand, he speaks of the interval between the spawning periods of the same herring and concludes that this is always one year. He points out for example, that the Schley herring requires a year after spawning before it can again take part in reproduction, and that the same periods of the yearly course of life — fattening, maturing, spawning — occur in the ripe fish of all regions.

The most recent information with respect to the reproductive fertility in the herring is that given by Jenkins, 1902 (54). He found that it varied greatly and is of the opinion that this may be ascribed to the difference in age of the herrings examined.

Spawning-period: On the 1st March 1862, Allman collected herring-spawn in abundance in the Firth of Forth at a depth of 14—21 fathoms: on the authority of Huxley (53).

In their Report of 1863, the English Commission on which Huxley was the zoologist, expresses the opinion quite clearly that the herring spawns at two periods of the year, in spring and autumn. In the months of June and December — the solstices — no spawning herring were found, and they seldom or never occur in May or in the beginning of July, in the second half of November or in the beginning of January.

A spring-spawning certainly takes place in the second half of January, in February, March, and April; and the autumn-spawning lasts from the second half of July to November. The shoals of spring and the autumn herring are according to Huxley, probably quite distinct from one another.

Mitchell (74), in his book published in 1864 declares that the herring began to spawn about the 30th August on the grounds not far from Dunbar, and that the fishermen on the 3rd September observed a large quantity of spawning herring on ground which was of a rocky or stony nature. (Cited by Cossar Ewart.)

Boeck (5, b and c), studied the Norwegian herring fishery in the years from 1860—70, and declares that the spring herring have strongly developed, the larger so-called ‘Fett-herring’ slightly developed sexual organs. The spring herring spawn in spring, the ‘Fett-herring’ later;

only towards the end of the fishing were the large herring found with ripe or nearly ripe sexual organs.

Widegren (1870) announced (97), that the herring of the Baltic spawn parly in spring and partly in summer, and that on account of this he had distinguished between spring and summer herring. In the southern parts of the Baltic the spawning continues till the middle of October, in the northern parts only till August.

Ljungman, 1878 (63, a), says that the small herring in the central parts of the Bohuslän coast begin to spawn at the end of May or 1st of June. In the northern parts the spawning begins perhaps a little earlier, in southern parts a little later; these quite small herring however, appear to be no other than sprats.

The spawning of the herring in the western Baltic was studied by Kupffer and Meyer in the seventies, and a detailed report was published by them in 1878. These studies were continued later by Heincke (37, a). They determined that as regards the spawning-period of the herring of the western Baltic, we have to deal with two varieties; in the one case, containing numerous representatives, of a variety spawning in spring in the brackish waters of the Schley and mouths of other rivers, in the other case with fewer representatives, of a variety spawning in autumn in the salt water.

Hinkelmann (44), has recently observed the spawning of the spring herring in the Kaiser Wilhelm (Baltic to North Sea) canal and describes it in an exact manner.

Cossar Ewart, 1884 (22, a; p. 65), collected spawn of herring on the west coast of Scotland (Ballantrae Bank). On another occasion¹) he states that he examined the spawning places in the Moray Firth in autumn and found them thickly covered with algæ and *Sertularia*.

The observations on the Ballantrae Bank were made on the 7th and 8th of March, 1884; so far as regards the herring, these observations seem to have been discontinued on the Scottish coast after that year, and later data concerning the spawning period of the Scottish herring are absent from the Reports of the Fishery Board. Information with regard to the spawning period of the herring on the English and Scottish coasts is indeed neither abundant nor definite.

In his work of 1887 (16, b; p. 98), Cunningham speaks of herring eggs which were collected in August "off the Longstone Lighthouse, Fearn Islands".

In their detailed treatise on the development and natural history of the bony fishes, M'Intosh and Prince, 1889 (72; p. 857), say that their observations tend to indicate that at least two spawning-periods occur in the neighbourhood (of the Scottish coast).

¹) On the Natural and Artificial Fertilisation of Herring Ova. Proceed. of the (Edinburgh) Royal Society, No. 231, 1884.

Through the researches of Hoffmann, 1881 (48, a; p. 7), and of Hoek, 1890 (47, b; p. 236), it was determined that the Zuyderzee herring are spring spawners, but that the spawning does not begin as a rule before the middle of April. Hoek found one of the spawning places in the Zuyderzee still richly covered with spawn on the 24th May (1888).

Bourne, 1890 (6; p. 377), published a note on herring larvæ which had been fished on the 3rd March in the North Sea, E. N. E. from Yarmouth.

Heincke[1]) observed herring with running spawn in September 1889 and 1890 on the Jutland Bank, near Heligoland, and at other parts of the North Sea. He remarked upon the occurrence of numerous large herring larvæ in the winter months in the neighbourhood of Heligoland, and considered these as the young of autumn herring.

Cunningham, 1892 (16, h; p. 240), says quite definitely that no observations were known to him of herring spawning in the neighbourhood of the mouth of the Thames in spring. He only knew of herring which spawned in the neighbourhood of Ramsgate in October and November. If one however, takes the size of the larvæ into consideration one is obliged to think that there are also herring which spawn in the neighbourhood of the mouth of the Thames in spring.

Petersen in 1892 (80, a; p. 140), published a note on the spawning of the herring in May and June in Holbæk-fjord, Isefjord, etc., and mentioned the months April—June as the spawning-period of the spring herring in Danish waters. In the first days of April he fished near Stege (Moen) some herring larvæ just hatched, and in August 1898 (80, f; p. 37), he observed the spawn of the autumn herring near the island of Vresen not far from Nyborg. This is the only time that he has found the spawn of the autumn herring in Danish waters.

Cunningham, 1896 (16, n; p. 154), says that the chief spawning period of the herring south from Aberdeen as far as Northumberland is in August and beginning of September; further south it begins later e. g. on the Yorkshire coast it is in October, and off Lowestoft and Ramsgate in November. The spawning-places however, are not known for certain.

The same author (p. 151) states that there are herring which spawn in winter, and others which spawn in summer or autumn, and that the herring which spawn at different periods of the year belong to different races. He mentions the Firth of Forth and Ballantrae Bank as examples of spawning places of winter (or spring) herring, and Kilbrennan Sound and the neighbourhood of Campbeltown for the herring spawning in August and September.

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[1]) Mittheil. der Sektion für Küsten und Hochseefischerei des d. Fischerei-Vereins 1890, p. 23 and 1891, p. 26.

Holt, 1899 (Jour. Mar. Biol. Associat. N. S. V.; p. 184), states (aut. Matthias Dunn) that very numerous young herring larva were observed on the surface, 4 to 5 miles off the coast of Cornwall on the 14th January. Like that of Bourne in 1890, this note refers to herring which spawn in late autumn or winter.

Spawning-regions: The most of what is known concerning the spawning-regions has already been given in dealing with the literature of the spawning-period. The number of the notices with regard to the spawning-regions, which rest on scientific observations, does not seem to be very great.

1862. Allmann, commissioned by the Scottish Fishery Board studied the spawning of the herring in the Firth of Forth and found a spawning place in depths of 26 to 36 m, on rough rocky ground near the Isle of May.

1870. Widegren (97) says that the herring spawn partly at some distance from the coast on elevations in depths of 5,5 to 27 m, partly quite close to the land, in fjords, and especially in places where the ground is covered with sea weed.

1874. Ljungman (63, a) is of the opinion that a 'clumpy' bottom forms the best spawning ground for the herring. It also spawns on mud or clay if this is overgrown with sea weed. He enumerates the best known places on the Swedish coast.

1878. Kupffer (59, a) studied the spawning of the spring herring in the Schley and of the autumn herring in the Great Belt and on the Mecklenburg coast.

1884. Cossar Ewart (22, a) gives precise data with regard to a certain spawning ground (Ballantrae Bank) on the west coast of Scotland. The depth varies between 8 and 12 fathoms, i. e. 14,5 and 21,6 m. The ground there is hard and the greater part of the spawn is laid "on flat areas covered with coarse sand or gravel". On the east coast of Scotland, however, the herring seems to prefer hard ground richly covered with *Hydrallmannia* and allied Hydrozoa.

This naturalist discusses the fact that certain spawning places are avoided by the herring during longer or shorter periods; Widegren, 1871 (97) also makes mention of this.

1889. Hoek (47 b) says that the spawning places in the Zuiderzee were found to be in shallow water where the ground was muddy or sand and mud.

1896. Cunningham (16, n) speaks of herring which spawn in Kilbrennan Sound and in the neighbourhood of Campbeltown without further describing these spawning grounds. At Plymouth according to him, the spawn is found only in Bigbury Bay; he never suc-

ceeded however, in getting the spawn from the ground. The spawning places of the autumn herring on the east coast of Scotland are not well known according to him, and this also is the case with the majority of the spawning places on the English coast.

1898. Heincke (37, c) recounts what is known of the spawning grounds up to the present time. As regards the depth of the spawning places the general opinion prevails, that the herring which spawn in spring prefer the shallow grounds near the coast where the water is often brackish; that the herring which spawn in summer or autumn have their spawning places in greater depths in the open sea. "The only thing common to all is that the spawning ground is always clean and firm, never shifting nor covered with mud" (p. 46).

1899. Hinkelmann (44) describes the spawning places of the herring in the Kaiser Wilhelm canal. They are on stony slopes of the canal grown over with algæ, just under the surface of the water down to a depth of 2 to 3 m.

1901. Petersen (80, f) enumerates the places in Danish waters which might be regarded as spawning grounds; the Isefjord, north from Ourö and near Refsnæs-Revet; near Knudshoved (Nyborg); near Sprogö and Vresen; in the Limfjord (Nissum Bredning); near Stege (Island of Moen).

Eggs: Boeck, 1871 (5, c), says that the diameter of the herring egg before it has absorbed water, is 1,5 mm. He observed the two layers of which the egg capsule is composed and the radiate marking on the inner membrane, and describes the micropyle though this according to him is difficult to see, and so on.

Kupffer 1878 (59, a; p. 177), describes the egg of the Baltic herring as nearly spherical. The diameter is 0,92 to 1 mm. Some eggs however are smaller, the smallest being 0,85 mm. The egg consists of three parts; the capsule, a viscous substance which covers the surface of the egg, and the yolk. The viscous substance which covers the surface, causes the eggs to adhere to one another and to whatever object they fall on. This layer is evenly spread round the egg as it leaves the ripe female. Kupffer describes in great detail the double-layered egg capsule as well as the yolk.

Hoffmann[1]) says of the ripe egg of the Zuiderzee herring, that it is perfectly transparent, and that it is surrounded by a thin layer of a substance which, when it comes in contact with water, becomes much swollen and adhesive. The eggs thus fix themselves firmly to the objects on which they fall.

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[1]) Verslag Staat Nederl. Zeevisscherijen voor 1878. 1879. S. 143.

In 1881 the eggs and especially the egg membranes and first developmental stages of the Zuiderzee herring were described by Hoffmann (48, a) in detail.

Cossar Ewart, 1884 (22, a), describes the deposition and fertilisation of the egg, but gives no data with regard to their size or constitution.

Cunningham, 1896 (16, n; p. 157), says that the size of the eggs from Ballantrae Bank reached 1,5 mm. The egg is spherical, but the surface flattened where it comes in contact with the bottom.

Hensen and Apstein, 1897 (40; p. 37), with the assistance of the material of the "Kommission zur wissenschaftlichen Untersuchung der deutschen Meere", published some measurements of herring eggs from Rügen. The size of the eggs was 1,125—1,35 mm, on the average 1,238.

Holt, 1898 (49, g; p. 154), publishes some notes on very large herring eggs, partly normal, partly abnormal. The largest normal eggs had a diameter of 1,76, the abnormal as much as 2,42 mm. These specimens however were all dead; the excessive size was confined to the perivitelline space, though it cannot be said that dead herring eggs in general have this space larger than living eggs.

Development: The excellent work of Kupffer, 1878 (59, b), is the first which has to be mentioned in reference to the development of the embryo in the egg. The researches of Hoffmann, 1881 (48, a), and of George Brook, 1885 and 1886 (7, a and b), agree well with his. For the post-embryonic development, the treatises of Meyer (73, a), and Kupffer (59, a and b), those of Heincke, 1878—1882—1898 (37, a and c), and Hoek, 1888—1890 (47, a, b and c), specially merit study.

Boeck (5, c), who gave the diameter of the herring egg as 1,5 mm, says that the herring larva just hatched has a length of 10 mm; according to Kupffer however this length is only 5,2—5,3 mm (Schley-herring); according to Hoffmann the length of the larvæ of the Zuiderzee herring (artificially reared) is 6,2—6,4 mm. The smallest herring larva obtained by Hoek in the Zuiderzee was 7,25 mm long and provided with a yolk sac of considerable size. M'Intosh and Mastermann 1897 (71; p. 412), say that the larvæ caught in the beginning of March in St. Andrews Bay, and which have just hatched, have a length of 7 mm.

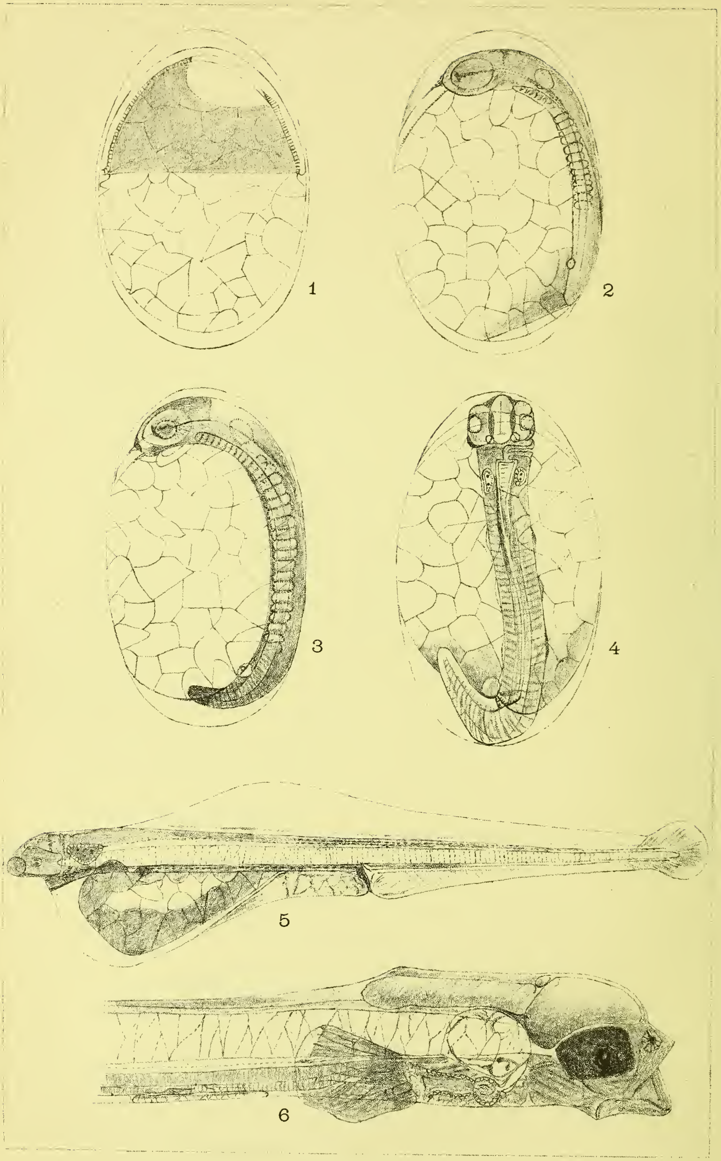
These authors mention also the observations of Meyer (73, a), who succeeded in obtaining a larva of 9 mm in length on hatching, by the same means which retarded the development of the egg, namely a lowering of the temperature.

The herring of the Schley, the spring herring of the western Baltic in general, the Zuiderzee herring etc. change from the larval form to that of the adult fish at a length of 35 to 36 mm. The autumn herring, both of the Baltic and North Sea, reach a length of 46 to 48 mm as larvæ, and only at that length change into the adult

form. The researches begun by Meyer and Kupffer in the Baltic and continued by Heincke, have so far as this point is concerned, received full confirmation through the studies of Hoek (Hollands Deep, Zuiderzee).

For the further development of the herring, the observations of M'Intosh and Masterman 1897 (71; p. 414), must also be referred to. According to them, the larva whilst still possessing the yolk sac lives near the bottom; but when the yolk sac is absorbed and a length of 10 mm is attained, it goes up into the midwater layers where it remains until it has a length of 12 to 16 mm; then the post-larval form seeks still higher layers and remains on the surface till a length of about 25 mm is attained. At this length the young herring come in masses to the coast, and soon afterwards at a length of 26 to 28 mm begin to shew the silvery sheen of the adult; when the young have quite assumed their scales the herring have then reached the "whitebait-stage". These authors compare the young of the spring herring with those of the autumn herring, and say that the size of the larvæ of the autumn herring is distinctly smaller on hatching than that of the spring herring. Considerable space is then devoted to the discussion of the variation in the rate of growth of the herring, a subject already dealt with by Masterman alone, 1896 (67, b; p. 294).

Lastly, to complete the list of works dealing with the rate of growth of the herring, the paper of Jenkins on the determination of the age of *Clupeidæ*, 1902 (54) is worthy of special mention.



AXEL F. AAMODT KJØBENHAVN.

10. *Engraulis encrasicholus, L.*

10. Anchovy: *Engraulis encrasicholus*, L.

Plate X

Common Names:

Danish: Ansjos.
German: Sardelle, Echter Anchovis.
English: Anchovy.
Finnish: Ansjovis.
French: Anchois.
Dutch: Ansjovis.
Norwegian: Ansjos.
Russian: Antschous.
Swedish: Ansjovis.

Description of the species: See the works of Günther (36), Kröyer (58), and Day (18); for short diagnoses, Collett (15), and Möbius and Heincke (76, b).

For the natural history of this fish in general, consult the researches of the Dutch naturalists (Hoffmann, Weber, Hubrecht, Wenckebach, Hoek), published in the "Verslagen van den Staat der Nederl. Zeevisscherijen" (48, b and c, 52), as well as the later works of Ehrenbaum (21, a), and Hoek (47, d, f and g).

Areal Distribution: Northerly: as far as Bergen on the Norwegian coast, Collett (15). Unknown on the American coast. On its occurrence in Scottish waters see Wemyss Fulton, 1890 (31, e; p. 351), and 1902 (31, o; p. 539).

Easterly: in the Baltic as far as the Kattegat and north coast of Zealand, at Hornbaek, Kröyer (58). On the German coast, as far as Travemünde Bay, Möbius and Heincke (autor. Lenz) (76, b; p. 143).

EXPLANATION OF PLATE X

Fig. 1. Egg, at the end of the first day. ×50.
„ 2. Egg, at the beginning of the second day. ×50.
„ 3. Egg, middle of the third day. ×50.
„ 4. Egg, beginning of third day, seen from above. ×50.
„ 5. Larva, just hatched. ×30.
„ 6. Anterior portion of larva, 4 days after hatching. ×30 (?).

All the figures are from Wenckebach, 1887 (96; fig. 1, 2 a, 3, 5 a, 6 and 7).

Southerly; south coast of England; along the west coast of Europe to Portugal; very general in the Mediterranean as far as the coasts of Greece and in the Black Sea.

Westerly; on the Lancashire coast of England only a few occasional specimens appear, HERDMAN and DAWSON, 1902 (42; p. 60); the western entrance of the English Channel, and according to CUNNINGHAM, 1896 (16, n; p. 182), the coast of Ireland.

(N.B. Within recent years the English have several times endeavoured on their coasts to participate in the anchovy fishery. CUNNINGHAM, 1890 (16, d; p. 334), describes the possibilities of such a fishery and, states what is known with regard to the occurence of the anchovy on the English coast. In 1895 (16, m; p. 300), the same author reports on the facts so far known with regard to the occurrence of the anchovy in the English Channel. He considers it probable that the anchovy which spawns in June and July on the Dutch coast, is the same as that found in autumn and winter in the English Channel. He does not believe, however, that anchovy fishing in the Channel would be profitable).

Bathymethric Distribution: It probably never lives at great depths. The fishing apparatus are such as are used for the catch of pelagic fish; "A truly pelagic fish, a fish which lives and feeds entirely in the open waters, having no direct relation to the bottom or the shores of the sea": CUNNINGHAM, 1890 (16, d; p. 332).

Food: According to KRÖYER, (58; III, p. 234), the anchovy feeds on worms and fish eggs.

From a study of the fish caught in the southern parts of the Zuiderzee, HOFFMANN, 1886 (48, b; p. 161), came to the conclusion that the food of the anchovy consisted entirely of small crustacea (larvæ of shrimps, gammarids, and copepods).

WEBER, 1887 (52; p. 198), was able to confirm the results of HOFFMANN; he found however, from 80 specimens of this species caught near the island of Texel close to the entrance from the North Sea, that the anchovy also fed on fish-larvæ and young fish: the stomachs of many were empty, but in several examples he found nothing but small specimens of the viviparous blenny (*Zoarces viviparus*) of 4 cm, and small flatfish of 1,5 to 2 cm in length.

EHRENBAUM 1892, found that the stomachs of anchovies caught in the Dollart contained mainly crustacea, copepods and *Podopsis Slabberi*, also young shrimps¹).

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¹) EHRENBAUM, Bericht über die von der Sektion für Küsten- und Hochseefischerei im Mai und Juni 1892 veranstaltete Versuchsfischerei auf der Unterems. Mittheil. der Sektion f. Küsten- und Hochseefischerei des deutschen Fischerei-Vereins. 1892. S. 162—185 (p. 178).

Reproduction: The females are in general larger and heavier than the males. It is stated by Hubrecht and Weber 1887 (52; p. 198), that out of 991 specimens 530 were males and 461 females; Hoffmann 48, b), however, came to the conclusion that the males were much less numerous than the females.

The sexually ripe fish in all probability are not of the previous year's brood but two years old, Ehrenbaum, 1892 (21, a; p. 13), and Hoek, 1897 (47, d; p. 13).

Spawning-period: The anchovy of the Mediterranean spawns somewhat early (in April), but in the North Sea and the inland seas connected therewith (Zuiderzee, Dollart, etc.) it is not ripe before the beginning of June.

On the 17th July 1886, according to Wenckebach (52; p. 188), the anchovy eggs were still exceedingly numerous in the northern Zuiderzee between Wieringen-Stavoren and Hindeloopen. On the 19th July 1888 all the females caught in the Zuiderzee had spawned, Hoek 47, c; p. 78).

In the beginning of July 1891, Ehrenbaum (21, a; p. 10 and 11), found a very large number of anchovy eggs — 16,000 in three hauls with the surface net — in the North Sea, a few miles from the island of Norderney. The same naturalist succeeded in obtaining floating eggs of the anchovy on the 10th June 1902 in the upper part of the Dollart, and on the 16th June, 1902 on the Ems off Termunten[1]).

Hoek (47, f; p. 27), observed numerous floating eggs of the anchovy on the 6th June 1893 in the northern portion of the Zuiderzee. The largest number was taken by him on the 22nd June.

According to Heincke and Ehrenbaum, 1900 (38; p. 265), the spawning time of the anchovy is in June and July.

Spawning-regions: Day (18) 1884, asserts that the anchovy breeds off the English coasts from September to December.

According to the observations of the Dutch naturalists the northern portion of the Zuiderzee forms an important part of the spawning-region of the anchovy. The floating eggs were for the first time observed here (1886), and whenever they were sought for in later years (1888 and 1893, June and July) they were always found again at the same place. The salinity of the water places a limit on the distribution of the eggs in the Zuiderzee; they are only numerous in water whose specific gravity is 1,015 and greater, Hoek, 1894 (47, f; p. 26).

Raffaele, 1888 (81) found the eggs of the anchovy in the Bay of Naples and says that this fish spawns from May to September.

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[1]) Mitth. der Sektion f. Küsten- und Hochseefischerei des deutschen Fischerei-Vereins. 1892. S. 179.

A fortunate discovery by Ehrenbaum (21 a; p. 10), on the 7th July 1891 shews that the anchovy also spawns in the open North Sea; 7 nautical miles N.N.W. from Norderney, he found a very large number of the eggs of this species floating in the sea, and on this observation he bases his conclusion that the real spawning-regions of the anchovy lie out in the North Sea although not very distant from the coast.

Ehrenbaum, 1892 (loc. cit.) found the spawn of the anchovy in the upper part of the Dollart and on the Ems off Termunten.

So far as the information goes the pelagic eggs of the anchovy have only once been observed on the English coast: this was on the 26th June 1896 not far from Lytham in Lancashire on the west coast of England, according to Mc Intosh and Masterman, 1897 (71; p. 405).

Eggs: The pelagic eggs of the anchovy were first observed by Wenckebach in 1886 (96), and according to him they have an oval (egg-shaped) form; their longest diameter is about 1,10 mm., their shortest 0,70 mm, the dimensions vary but slightly. Further, the egg can easily be recognised from the total segmentation of the yolk and because the embryo lies parallel to the major axis of the ellipsoid.

According to Raffaele, 1888 (81), the size of the anchovy egg is 1,10 to 1,45 mm by 0,45 to 0,66 mm.

Williamson, 1898 (98, c; pl. VIII and IX), has given good figures of the anchovy egg and embryo.

According to Heincke and Ehrenbaum, 1900 (38; p. 265), the anchovy has an egg of ellipsoidal form with homogeneous yolk without oil-globule. The larger diameter is 1,1 to 1,5 mm, and the smaller 0,7—0,9 mm. Pigment is absent from the embryo; anus lies somewhat behind the middle of the body.

Development: According to Wenckebach 1887 (96), the larva of the anchovy hatches out in three days. The larva just hatched is quite transparent and without pigment, and has a length of 4 mm. The yolk sac is much elongated and extends backwards to a point. The notochord is relatively broad; it is characteristic, according to Wenckebach, that the anterior end of the chord is bent perpendicular towards the ventral aspect of the fish.

Wenckebach also observed the lateral organs of the anchovy larvæ and gives a drawing of them; he remarks that he was unable to discover fine cilia or "Cupulæ terminales" on these organs. (See below, Williamson).

According to Cunningham, 1896 (16, n; p. 183), the larva just hatched is only a little over 2 mm. long, after 36 hours however the length was 3,6 mm.

Hoek found that larvæ from the Zuiderzee which he determined as those of the anchovy, had a length of barely 2,5 mm.

At the same place but later Hoek, 1894 (47, f; p. 39), found older larvæ of 10 mm which he believed to belong likewise to the anchovy. Earlier data are given by Hoffmann, 1887 (48, c; p. 176), with respect to fish-larvæ from the Zuiderzee which were 16—30 mm, long and were taken in the pelagic net on the 27th—31st July. These were also considered anchovy larvæ by this naturalist. No information is given by the latter as to the number of specimens obtained, those taken by Hoek were not numerous.

The smallest fish — no longer larval — observed by Hoek in the Zuiderzee, was 34,4 mm, long and had quite the appearance of a small anchovy, its mandible for example, showed already the characteristic elongation. At this size it is still imperfectly covered by scales. Hoffmann, 1887 (48, c; p. 176), says that 32 mm is the smallest size at which the fish can clearly be recognised as an anchovy. Fish of this size are extremely rare in the Zuiderzee. In late summer and autumn according to Hoek, 1894 (47, f; p. 24), it is not a rare occurrence however for one to find there young anchovies of the following dimensions: 40—60 mm long in the middle of August; 60—117 mm, average 85 mm, at the end of August; 78—115 mm, average 94 mm, at the end of September; 75—95 mm, in the middle of November. In opposition to Hoffmann's opinion that these were born in the summer of the same year, Ehrenbaum (1892) and also Hoek (1893) assert that they must be one year old fish which have wandered in from the North Sea.

Williamson, 1898 (98, c; p. 211), has given the most recent information with regard to the development of the anchovy. He studied the eggs of this species in the Zoological Station at Naples, and states that he has observed a circulation of the yolk-spherules in the egg. These spherules according to him are very large, twice as large as ordinary blood corpuscles. The strongly developed lateral papillæ which he observed on the anchovy embryo, are however specially remarkable. In a larva just hatched the small pear-shaped corpuscles were attached to the papillæ, and there is usually a delicate tube projecting from each papilla at right angles to the side of the embryo. The distal portion of the tube is bent backwards. There are seven papillæ on the right and six on the left side.

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